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SIGNATURE EXTENSION FOR SUN ANGLE

VOLUME T

Les.

J. A. Smith, J. K. Berry, and F. Heimes

Final Report
Earth Observations Division
NASA Johnson Spacecraft Center
NAS 9-14467

(E76-10272) SIGNATURE EXTENSION FOR SUN ANGLE, VOLUME 1 Final Report, 15 Nov. 1974 - 14 Nov. 1975 (Colorado State Univ.) 111 p HC \$5.00 CSCL 03B

N76-21639

Unclas G3/43 00272

November, 1975

Department of Earth Resources Colorado State University Fort Collins, Colorado 80523

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VOLUME I

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Department of Earth Resources Colorado State University Fort Collins, Colorado 80523 THE FINDINGS IN THIS REPORT ARE NOT TO BE CONSTRUED AS AN OFFICIAL NASA POSITION, UNLESS SO DESIGNATED BY OTHER AUTHORIZED DOCUMENTS.

ABSTRACT

This is the first volume in a two-volume final report series for Project NAS 9-14467 sponsored by the Earth Observations Division, NASA/JSC. This report series summarizes the work covered between the period November 15, 1974, and November 14, 1975. The objectives of the project were to evaluate the LACIE II table look-up approach to sun-angle correction. Canopy reflectance modeling was employed as a technique for evaluating sun-angle signature extension.

Volume I presents the multiplicative and additive coefficient matrices for a linear sun-angle correction approach. These coefficient tables are calculated using either measured empirical canopy reflectance functions or model derived data. These values are then incorporated into an atmospheric radiation transfer model. The dependence of the coefficient matrices on crop stage, crop type, and canopy directional reflectance variations is reviewed. Finally, a method for inferring leaf area index, an intrinsic scene characteristic, from canopy reflectance is discussed.

Volume II presents the basic data and computer programs used in the study. A brief review of the radiometric and geometric data collection procedures is also given. In particular, two recent methods developed by the investigators for determining plant geometry are discussed. These include the Fourier diffraction and multiple view angle approach. The data compilation consists of canopy reflectance, constituent reflectance, Leaf-Area-Indices, and leaf slope distributions for four wheat crop development stages at Garden City, Kansas.

FOREWORD

The research described in this report was supported under contract NAS9-14467, issued by the National Aeronautics and Space Administration, Earth Observations Division, Johnson Spacecraft Center, Houston, Texas. Mr. T. Barnett was the technical monitor of the project. The efforts described in this report represent Task 4.1.1.2 f(S) described in LACIE 00200, Volume III. Field data for the project were gathered over the LACIE Intensive Test Sites in Garden City, Kansas. The measurements were performed in cooperation with Dr. J. C. Harlan, Remote Sensing Center, Texas A & M University. Mr. Barrett Robinson, Laboratories for Applications of Remote Sensing, Purdue University, constructed the diffuse radiometer attachment for measuring leaf transmittance.

Participating project personnel included Dr. James A. Smith, Department of Earth Resources and Principal Investigator; Mr. Joe Berry, Graduate Research Assistant, and Mr. Rick Heimes, Graduate Research Assistant. Other project personnel included Miss Carol Conrad and Mrs. Pam Solomon, Colorado State University, who assisted in preparing the final report. Mr. Berry received the degree, Doctor of Philosophy, for work related to project sub-tasks.

The authors would particularly like to express their appreciation to Dr. Harlan and his research team for their field measurement support and to Dr. A. E. Potter, Chief of the Research, Test, and Evaluation Branch, Earth Observations Division, under whose auspices this work was performed.

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I. INTRODUCTION

This is the first volume in a two-volume final report for NAS 9-14467 which represents Task 4.1.1.2f(s) in the LACIE 00200, Volume VIII. Specific objectives of this task in order of priority include:

- A. To evaluate the current LACIE II table look-up sun angle correction algorithms relative to:
 - 1. The effect of canopy reflectance variations with sun angle;
 - The effect of canopy sun angle reflectance variations with crop development stages;
 - The effect of applying a uniform sun angle correction developed specifically for wheat to all crop types.
- B. To recommend modifications to the current LACIE II sun angle correction algorithm.
- C. To investigate alternative sun angle correction procedures for present and future satellite systems. In particular, to investigate the possibility of extracting intrinsic scene characteristics from wheat canopy modeling.

The current LACIE II sun-angle correction algorithm is based on the fundamental assumption that the radiance detected by LANDSAT at one sun angle, θ_{j} , is linearly related to the radiance detected at another sun angle, θ_{j} . That is, for each MSS band:

Consequently, the mean vector and covariance matrix determined from one training segment at sun angle $\Theta_{\bf i}$ may be adjusted for data collected at a

second sun angle θ_j , by matrix transformation of the training statistics. This is accomplished by employing a diagonal matrix of alpha coefficients, \underline{A} , and a diagonal matrix of Beta coefficients, \underline{B} , as discussed in Section II. In practice, the algorithm consists of calculating appropriate tables of alpha and beta coefficients for each multi-spectral band at five degree increments. These coefficient matrices are calculated using the Turner atmospheric radiation model (Turner, 1973) for those sets of sun angles available from the field collected data and for all sun angles using SRVC canopy reflectance model data (Oliver and Smith, 1974). Tables for each crop development stage are calculated using both Lambertian and directional reflectance properties of the canopy. The effects of changes in canopy reflectance resulting from crop type variations are also discussed.

Section III reviews the use of the SRVC canopy reflectance model to generate wheat canopy reflectance curves as a function of sun angle crop stage. The model is calibrated and compared with field data. Section IV summarizes some predictive relationships relating leaf area index, an intrinsic geometric parameter of the canopy, and canopy reflectance. Conclusions and recommendations are given in Section V.

Volume II of this final report series includes a description of field data collection techniques; a complete listing of the radiometric and geometric data, and computer program listings and descriptions that were employed in this study.

The techniques developed for measuring plant geometry and the data compilation for the test sites at Garden City, Kansas, for each of four crop development stages should be of particular and general interest.

II. SUN-ANGLE SIGNATURE EXTENSION

This section describes the procedure used in developing the multiplicative and additive coefficients of the linear correction algorithm for sun-angle effects. Figure I summarizes the interactions affecting the recorded radiance (LT) at the satellite sensor. In mathematical terms,

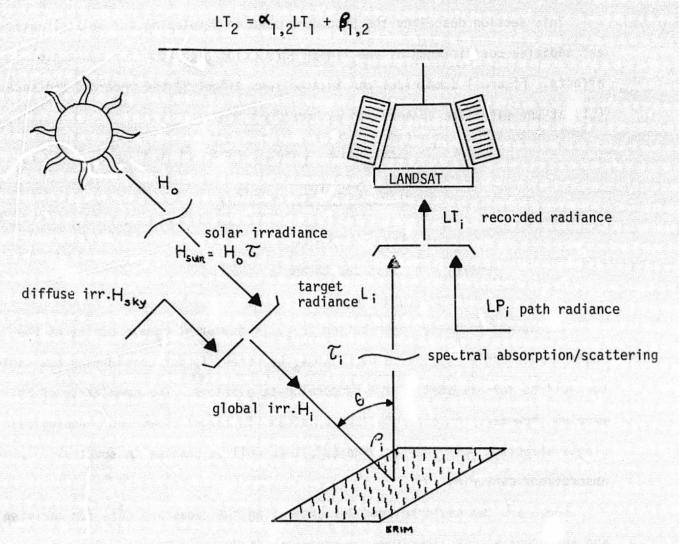
LT_{i2} =
$$\frac{P_{i2}}{\pi}$$
 $\frac{\gamma_{i2}}{\pi}$ (H_{sun} cos θ + H_{sky}) + LP_{i2}
= $\frac{P_{i2}}{\pi}$ $\frac{\gamma_{i2}}{\pi}$ + LP_{i2}
= L_{i2} + LP_{i2}
where, \dot{c} = solar zenith angle

The target radiance contribution $(L_{i\lambda})$ is dependent on the cosine of the solar zenith angle (θ) , which highlights the necessity for considering sun angle corrections for all spatial and temporal data overlays. The complexity of this problem, however, is compounded by variations in target types and phenological stages affecting scene reflectance $(P_{i\lambda})$, as well as changes in spectral absorption/scattering $(V_{i\lambda})$.

2 = wavelength

There are two basic methods for extracting the necessary data for deriving sun angle correction algorithms — empirical study and modeling. Both of these appraoches are presented in this report. Colorado State University's Solar Radiation-Vegetation Canopy (SRVC) model is used in the modeling approach. The plant canopy model generates surface reflectance values ($\mathcal{P}_{l,k}$) for varying sun angles, given certain intrinsic scene parameters (e.g., LAI, leaf angle distribution, consistent $\mathcal{P}_{l,k}$ and $\mathcal{V}_{l,k}$). These reflectance predictions act as input to an atmospheric model yielding target radiance, path radiance and total recorded radiance. This information can then be analyzed to identify the sun angle relationship.

The LACIE project currently assumes a linear correction model as follows:



recorded radiance
=(global irradiance * target reflectance * spectral absorption/scattering
+ path radiance)
=target radiance + path radiance

FIGURE 1. The Interactions of Solar Radiation

An estimate for \propto and β that is often employed when θ_1 and θ_2 are nearly the same is,

It appears that this correction is sufficient when θ_1 and θ_2 are nearly the same.

A more rigorous estimate of the \prec and β coefficients may be derived by the following procedure.

1. The equations for two different sun angles are:

2. Simultaneous solution of the two equations:

3. With the final solution form:

$$LT_{2} = LT_{1} \times_{1,2} + LP_{2} - LP_{1} \times_{1,2}$$

$$= LT_{1} \times_{1,2} + \beta_{1,2}$$

$$\text{where;} \quad \times_{1,2} = \frac{H_{2} R_{2} L_{2}}{H_{1} R_{1} L_{1}}$$

$$\beta_{1,2} = LP_{2} - LP_{1} \left(\frac{H_{2} R_{2} L_{2}}{H_{1} R_{1} L_{1}} \right)$$

4. These coefficients expressed in atmospheric modeling terms are:

5. By varying the input parameters of the SRVC model, temporal, spatial and crop type changes can be induced and the resultant target reflectance monitored. This reflectance variable is then used as input to an atmospheric model which solves for path radiance, target radiance and recorded radiance. Utilizing the equations cited in item 4, a complete set of tables of and 3

coefficients can be developed for specific scene characteristics and atmospheric conditions.

The following sections are concerned with three primary topics: 1) the calculation of \propto and β coefficients from field measured data; 2) the calculation of \propto and β coefficients from model derived data; and 3) an investigation as to possible sources of variation in the sun-angle correction procedure under study.

1.0 Correction Coefficient Matrices Calculated from Empirical Data.

Table 1 summarizes the solar angles coincident with field radiometer measurements for four phenological stages of wheat at the LACIE Intensive Site, Finney County, Kansas. A detailed discussion of the data collection procedures employed and a presentation of the data is made in Volume II of this report. This data set served as a foundation in deriving the empirically based correction coefficients.

Two fundamentally different approaches were used, which yielded two different types of coefficients. One approach determined the overall average canopy reflectance by calculating the mean reflectance for each LANDSAT band without regard to sun-angle or leaf area index variations. This method implies that the plant canopy acts as a Lambertian surface, and that all sun-angle effects are induced by atmospheric variables.

The second approach maintains sun-angle continuity by calculating a mean reflectance in each band for all plots having the same sun position at the time of measurement. This approach assumes that plant canopies display significant bi-directional reflectance. Canopy effects then combine with atmospheric effects to yield the overall sun-angle variations in sensor signals. Appendix B contains plots of the empirical data used in both approaches and Appendix C.1 presents the actual data.

For the Type I empirical coefficients (Lambertian), the Turner Atmospheric Model was executed using the grand mean reflectance for each sun-angle envelope

TABLE 1

SUN ANGLES (Degree Zenith) Occurring During Radiometric Data Collection

TIME (LOCAL)	MARCH 20	APRIL 23	MAY 20	JUNE 26
	11111011 20	MINIL LO		00112 20
0930	-	-	57°	-
1000	-	55°	51°	48°
. 1030	57°	49°	45°	42°
1100	52°	44°	40°	37°
1130	47°	39°	34°	31°
1200	4 4°	34°	29°	26°
1230	41°	30°	24°	21°
1300	39°	27°	20°	17°
1330	38°	25°	18°	15° ·
1400	39°	25°	18°	· ••
1430	40°	27°	-	-
1500	43°	31°	**	_
1530	47°	35°	-	-
1600	51°	40°	· - ·	· -
1630	56°	45°	· _	-
1700	ear .	51°	-	.
1730		56°	-	-
1800	••	62°	₩	_

indicated in Table 1. The Type II procedure involved executing the Turner model with the same sun-angle envelopes as with Type I, however, each sun-angle was matched with an empirical canopy reflectance corresponding to that sun-angle. The output in each case is a prediction of the path, target and total radiance at a satellite sensor under nominal conditions. These variables were used to solve for the individual α and β coefficients as described in the previous section. Appendix A.1.0 presents the Type I empirical coefficient matrices, while A.2.0 presents the Type II coefficients.

2.0 Correction Coefficient Matrices Calculated from Model Derived Data

A detailed discussion of the canopy model simulation procedure is presented in Section III of this volume. In brief, it employs Coicrado State University's SRVC model to predict a plant canopy's spectral reflectance, based on descriptive intrinsic and environmental variables. In simulating sun angle effects, the model's variables were fixed in accordance with field measurements, while the sun's position was varied from 5° to 70° (zenith). The result of this effort is a model derived data set similar to the empirical Type II (directional) data set discussed in the previous section. Appendix C.2 contains the model generated canopy reflectances as a function of sun angle for each phenology stage. The Turner model predictions of sensor radiance for the model reflectances were generated in the same manner as the Type II predictions. The \bowtie and β coefficient matrices are presented in Appendix A.3.0.

Figure 2 and Table 2 identify a terse comparison of corrected and uncorrected signatures for the April field data using the model derived correction coefficients. The procedure of the comparison involved using the Turner model to convert field reflectance measurements taken at different sun angles into radiance values. These data are shown in the left graph. The signatures were then corrected for sun angle variation using the 47° solar zenith angle signature as the correction base. The right hand graph shows the corrected data

1. 5

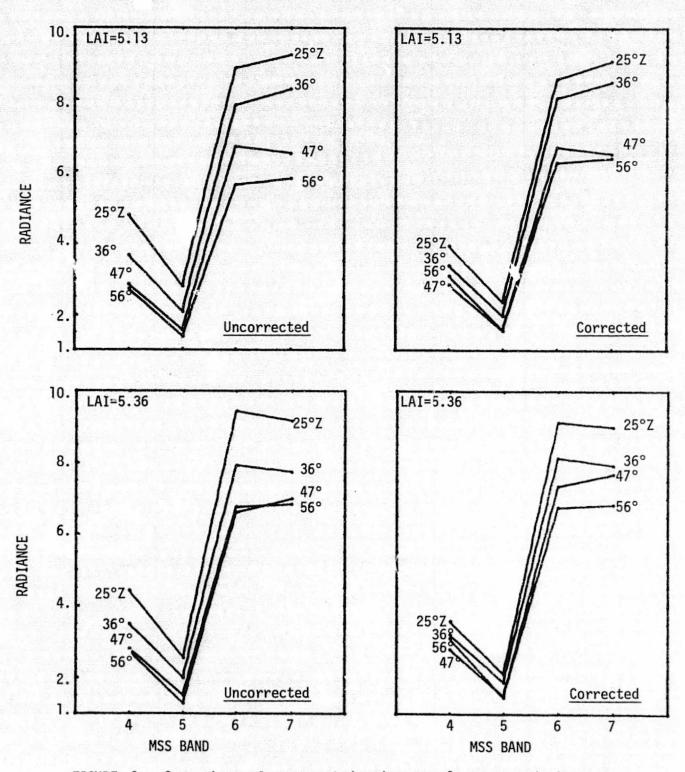
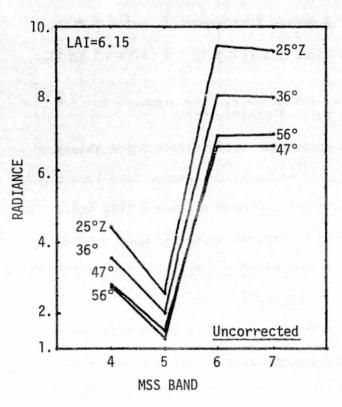


FIGURE 2. Comparison of uncorrected and sun-angle corrected signatures for April field data (47° solar zenith angle used as correction base)



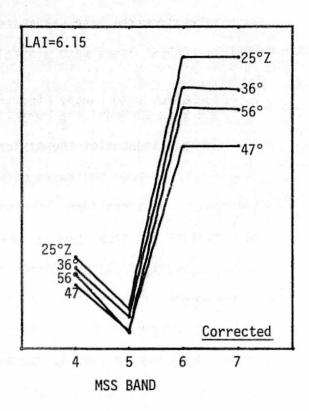


FIGURE 2. Continued

TABLE 3
MEAN SQUARED DEVIATION IN
SENSOR RESPONSE FROM BASE
SIGNATURE (47° SOLAR ZENITH ANGLE)

LAI	SUN ANGLE	MSS4	MSS4 CORR	MSS5	MSS5 CORR	MSS6	MSS6 CORR	MSS7	MSS7 CORR
5.13	25°Z	3.767	1.184	1.538	.646	4.827	3.602	7.557	6.693
	35	.654	.291	.264	.175	1.329	1.866	3.211	4.000
	55	.017	.063	.032	.001	1.115	.177	.479	.013
5.36	25	2.647	.616	1.071	.365	7.140	5.607	5.392	4.666
	35	.477	.172	.230	.144	1.336	1.885	.799	1.179
	55	.006	.091	.051	.002	.024	.349	.023	.717
6.15	25	2.634	.608	1.111	.388	7.862	6.245	6.975	6.140
	35	.558	.225	.247	.158	2.002	2.683	1.812	2.393
	55	.005	.099	.051	.002	.086	1.160	.101	1.020
Mean So Erro		1.20	.37	.511	.209	2.858	2.619	2.928	2.980

in which a compression of the extended signatures about the 47° signature is apparent. Table 2 summarizes the mean squared deviations of the extended signatures from the base signature. A marked improvement is noted for the visible LANDSAT bands with minimal success occurring in the infrared bands.

3.0 Variation with Canopy Directional Reflectance, Crop Stage, Crop Type and Between Model and Empirical Derived Coefficients

Table 3 identifies the differences between coefficients based solely on atmospheric induced sun angle effects and those which involve both atmospheric and canopy considerations. The comparisons are made by calculating the change in a typical radiance reading corrected by empirical coefficients derived by using an averaged canopy reflectance (Lambertian) and by using canopy reflectance values keyed to specific sun angles (directional). The table is organized by phenology stages, with comparisons for MSS bands 4 and 6 being made for each stage. Only two of the four bands are used because of the high correlation within the visible and near infrared bands. Differences are slight for the most part. It is hypothesized that the slight differences exhibited are a result of the fact that sun angles between 35 and 50 degrees tend to fall in the flat position of the reflectance curves for these wavelengths. To see if the hypothesis was correct, a difference was evaluated for the month of April from 35 to 60° sun angle, band 6, because this reflectance curve increases sharply between 55 and 60°. The result was that the difference between Lambertian and directional corrected values increased from a negligible percentage between 35 - 50° sun angle to a difference of -21% between 35 - 60° sun angle. The difference between Lambertian and directional corrected values was 19% between 55 - 60° sun angle where the reflectance curve changed dramatically.

TABLE 3

COMPARISON OF LAMBERTIAN AND DIRECTIONAL EMPIRICAL COEFFICIENTS

BAND 4	BAND 6	
	MARCH	
40 45 50 35020405 400103 4502	40 45 50 35050912 400308 4503	
	APRIL	
40 45 50 35 .03 .04 .04 40 .03 .02 45 .00	40 45 50 60 35 .00 .01 .012 40 .00 .00 45 .00	21
	MAY	
40 45 50 35 .02 .04 .06 40 .02 .05 45 .02	40 45 50 35 .02 .04 .06 40 .02 .03 45 .03	
	JUNE .	
40 45 50 35 .03 .05 .08 40 .04 .05 45 .01	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	

It was further noted that when the reflectance curve declined as sun angle increased the differences between Lambertian and directional were positive percentages becoming larger with steeper slopes of the reflectance curves. Negative percent differences were exhibited when reflectance curves increased with increasing sun angle.

Table 4 considers the changes in corrected radiance readings induced by crop development. The change is reported in reference to the empirical directional coefficients for the March phenology stage (i.e., (March - X)/March). Comparisons are made for both a visible and near infrared band.

The percent changes between March and each of the other three months vary from 3% to 16% with a mean of about 8%. However, differences between the month of April, May and June are very slight. The sun angles used in this evaluation, 35-50 degrees, are in the flat portion of the refelctance curves for each month and each of the two wavelengths. The reflectance increases with increasing sun angle over the 35°-50° range during March and decreases with increasing sun angle over the 35°-50° range during the other three months. This crend holds true for both wavelengths, being somewhat more pronounced in band 7 than in band 5. This change in slope of the reflectance curves between March and each of the other three months over sun angles between 35°-50° (Appendix B) explains the larger differences in correction coefficients between March and other months. The slope of the reflectance curves for April, May and June, between 35-50° sun angle, vary only slightly from one to the other. This accounts for the slight differences in correction coefficients between April, May and June.

A comparison of the model and empirical derived correction coefficients is presented in Table 5. Both the empirical and model data sets used to derive the coefficients treated the canopy as having bi-direction reflectance. The tabular values represent the change in corrected radiance readings calculated by the two techniques. The empirical based corrections are used as reference (i.e., (empirical-model)/empirical).

TABLE 4

PHENOLOGICALLY INCITED DIFFERENCES IN DIRECTIONAL EMPIRICAL COEFFICIENTS

	<u>B</u>	AND 4					BAND 6	
	•			MARCH-APRIL				
	40 .05	45 .09 .05	.09 .06 .09		35 40 45	40 .05	45 .09 .03	50 .12 .07 .03
40			.03	MARCH-MAY	73			.03
	40	45	50			40	45	50
	.05	.09	.12 .08 .12	·	35 40 45	.07	.12 .05	.16 .10 .06
				MARCH-JUNE				
	40	45	50		25	40	45	50
35 ⁻ 40 45	.05	.08 .04	.11 .07 .10		35 40 45	.07	.10 .04	.14 .08 .05

TABLE 5

COMPARISON OF DIRECTIONAL EMPIRICAL AND MODEL CORRECTION COEFFICIENTS

BAND	4

BAND 6

MARCH

	40	_45	50
35	00	02	02
40		01	01
45			.00

	40	45	50
35	02	04	08
40		03	05
45			04

APRIL

	40	45	50
35	10	22	25
40		09	14
45			03

MAY

JUNE

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR The best agreement between the two approaches occurs for the March data, while the worst occurs in June. The overall comparison, however, notes an average difference of about 12%. The extremely large discrepancies in the June data are most likely a result of the insufficient radiometric data collected during this period.

The effects of crop type variations on correction coefficients were simulated by varying both the optical parameters of a canopy, i.e., the leaf reflectance/transmittance, and the leaf slope distribution. For this study, leaf reflectance values for barley and bean were selected from a field study by the USDA-ARS at Weslaco, Texas, (Gausman, 1971). To incorporate geometry effects, the leaf slope distribution for wheat was reversed, i.e., the probability density $p(\cos\theta)$ was changed to $p(\cos\theta) = p(\cos(\theta) - \theta)$.

Table 6 gives the calculated alpha and beta coefficients for the wheat, barley, bean, and "inverse" cases described above for MSS 4 and MSS 6. Three sun-angle combinations were employed, (10,35), (35,40), and (40,65) representing three different angle extension cases; two large sun angle extensions and a small range near median sun angles.

Table 7 summarizes the differences between each case compared to wheat as a reference. The linear correction coefficients in Table 6 were applied for typically occurring radiance values of 3.5 for MSS 4 and a value of 6.5 for MSS 6. In general, differences are slight in the visible band except for wheat/barley differences at low sun angles (high zenith values) where the canopy exhibits large non-Lambertian effects. However, differences of at least 10 percent are exhibited in the infrared band, MSS 6, at all sun angles for wheat/barley.

TABLE 6. Alpha and Beta Coefficient Matrices for Simulation Crop Type Study.

<u>Alpha Values</u>				<u>B</u> 6	eta Value	<u>es</u>	
MSS4	(10,35)	(35,40)	(40,65)		(10,35)	(35,40)	(40,65)
Wheat	1.03	1.04	0.80		-1.82	-0.26	-0.16
Barley	0.82	0.93	0.52	*	-1.04	-0.05	0.34
Bean	1.04	1.04	0.80		-1.85	-0.27	-0.16
Inverse	0.98	0.97	0.72		-1.64	-0.13	-0.02
	Alj	oha Value	<u>es</u>		<u> </u>	Beta Valı	ıes
MSS6	(10,35)	(35,40)	(40,65)		(10,35)	(35,40)	(40,65)
Wheat	1.06	1.03	0.85		-0.43	-0.07	-0.06
Barley	0.83	0.93	0.54		-0.22	-0.01	0.10
Bean	1.07	1.04	0.84		-0.43	-0.07	-0.05
Inverse	0.99	0.98	0.76		-0.36	-0.04	-0.01

TABLE 7. Comparison of Crop Type Variations Effects on Correction Coefficients

		Band 4			Band 6	
	(10,35)	(35,40)	(40,65	(10,35)	(35,40)	(40,65)
Wheat- Barley	02	.05	.18	.20	.09	. 34
Wheat- Bean	00	.00	.00	01	01	.01
Wheat- Inverse	00	.03	.05	.06	.04	.10

III. SIMULATION ANALYSIS

This section describes the modeling effort associated with the project's primary task of deriving sun angle correction techniques (Section II). It consists of two subsections: 1) a general comparison of model and empirical broad-band signatures for each phenological stage; and 2) a detailed presentation of sun angle induced variations in reflectance, for each phenological stage, as determined by both field measurement and vegetation canopy modeling. Each subsection consists of a tabular and graphical summary of the applicable data and a brief discussion of the more important aspects.

The model canopy reflectance predictions were made by Colorado State University's SRVC model which is described in detail in Volume II, Section IV.1. Basically, the model utilizes Monte Carlo techniques to trace the interaction of scene irradiance with the plant canopy, and estimate the resulting characteristic reflectance. The principle scene and environmental variables incorporated in the model, include leaf area index, leaf angle distribution, individual leaf transmission and reflectance, soil reflectance, diffuse/direct irradiance ratio sensor position, and sun location. Extensive field data were collected to estimate the intrinsic scene variables and establish an empirical data base in order to evaluate the model's predictions. The field procedures used and resulting data are described in Sections II and III of Volume II. Data were acquired for four phenological stages of wheat at the LACIE Intensive Site, Garden City, Kansas: 1) tillering, 2) jointing, heading, and 4) ripening. In simulating sun angle effects, all of the variables of the canopy model were fixed in accordance with the field estimates, while the sun position was varied from 5° to 70° (zenith). Table I identifies the input data for the model at each stage.

TABLE 1 INPUT PARAMETERS FOR SRVC MODEL

SUN ANGLE EFFECTS DATA CREATION - JUNE

	1 1010 1	MIN ONLINITO	311 0011E						
DAY 177 YEAR 1975 LAT. 38. LONG. 101. NSAMP 10 NTRIAL 5	DEC.	23.28	NCONST 1						
LAD (0-90°;5° incr.) 0. .001 .005 .011 .017 .147 .159 .143 .081 LA1 5.16	0. .026	.017 .046	.009 .075	.003 .099	0. .124				
DIFF./TOTAL IRRADIANCE* SOIL REFLECTANCE	.173	.085 .191 .230	.259 .433	.495					
SUN ANGLE EFFECTS DATA CREATION - MAY									
DAY 140 YEAR 1975 LAT. 38. LONG. 101. NSAMP 10 NTRIAL 5	TIME DEC. NLAY	0939* 20.03 1	NCONST 1						
LAD (0-90°; 5° incr.) 0. .006 .011 .014 .043 .120 .115 .101 .059 LAI 5.16	.035 .061	.027 .061	.010 .083	.007 .098	.006 .112				
NWAVE DIFF./TOTAL IRRADIANCE* SOIL REFLECTANCE LEAF REFLECTANCE LEAF TRANSMITTANCE	.55 .099 .160 .071	.65 .084 .196 .050 .050	.112 .275 .369	.95 .138 .319 .495 .495					
SUN ANGLE EFFECTS DATA CREATION - APRIL									
DAY 112 YEAR 1975 LAT. 38. LONG. 101. NSAMP 10 NTRIAL 5	TIME DEC. NLAY	12.93	NCONST 1						
LAD (0-90°; 5° incr.) .003 .037 .042 .052 .064 .090 .072 .036 .032 LAI 5.55	.009 .073			.032 .105	.034 .105				
NWAVE DIFF./TOTAL IRRADIANCE* SOIL REFLECTANCE LEAF REFLECTANCE LEAF TRANSMITTANCE	.55 .196 .186 .071 .071	.65 .172 .185 .050	.75 .174 .243 .369 .369	.95 .183 .299 .495 .495					

Table 1 (Continued)

SUN ANGLE EFFECTS DATA CREATION - MARCH

DAY 79 YEAR 1975 LAT. 38. LONG. 101. NSAMP 10 NTRIAL 5	TIME DEC. NLAY	0930* 08 1	NCONST 1		
LAD (0-90°; 5° incr.) .031 .034 .035 .041 .050 .082 .078 .065 .061 LAI 2.48	.032 .056	.030 .065	.033 .073		.034 .085
NWAVE DIFF./TOTAL IRRADIANCE* SOIL REFLECTANCE LEAF REFLECTANCE LEAF TRANSMITTANCE	.55 .109 .060 .071 .071	.65 .091 .077 .050 .050	.75 .102 .116 .369 .369	.95 .121 .143 .495 .495	

^{*}Value was changed as sun angle effects were simulated.

1.0 Comparison of Model and Field Data

Figures 1 and 2 show a comparison of field and model estimates of canopy reflectance at the four phenological stages of the study. In each case, an attempt was made to approximate the reflectance at time of a LANDSAT overpass. In general, it can be noted that the model was relatively successful in tracking the empirical data during the jointing (April) and heading (May) stages, while it was somewhat less accurate during the tillering (March) and ripening (June) stages. In reviewing this comparison, consideration should be given to the standard deviations for both the model and field values.

The primary sources of error in the March model predictions are most likely a result of the model's inability to adequately deal with the pronounced rowing effect at extremely low LAI's, and the strong contribution of a highly variable soil reflectance. In light of these potential problems, a review of the model is being made to determine the feasibility of making modifications to account for rowing effects. In addition, the field procedures for next year's measurements have been modified to insure a better representation of local soil reflectance.

The discrepancy in the June model and field signatures may be merely a reflection of inadequate empirical data. However, it does appear that the accuracy of individual leaf transmission and reflectance estimates is critical. The dramatic difference between the characteristic signatures of May and June emphasizes the dominant effect of the transition from live to dead leaf reflectance. In order to make better constituent reflectance measurements during the ensuing field season, an attachment for the LANDSAT radiometer is being designed in cooperation with Purdue University.

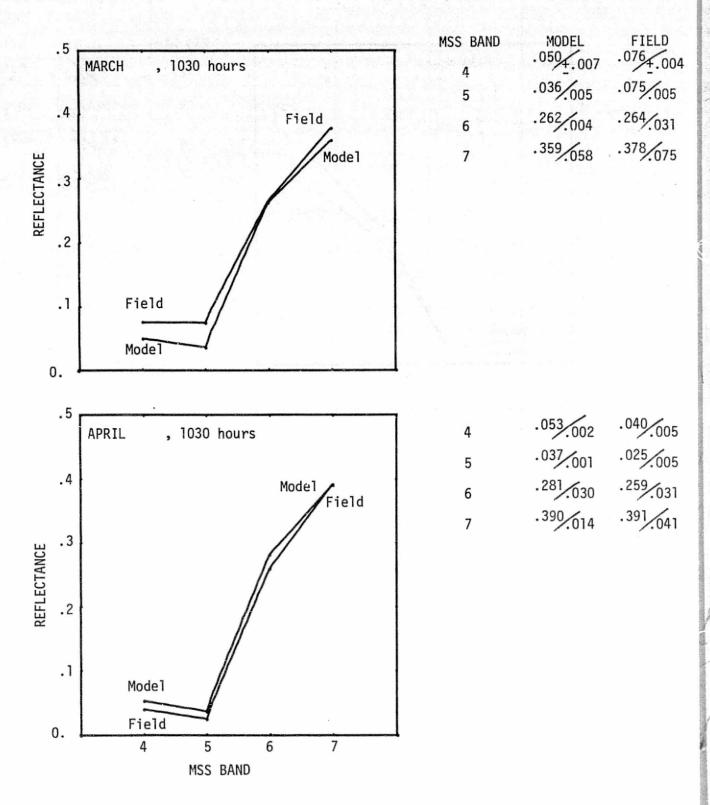


FIGURE 1. COMPARISON OF MODEL AND FIELD DATA FOR MARCH AND APRIL

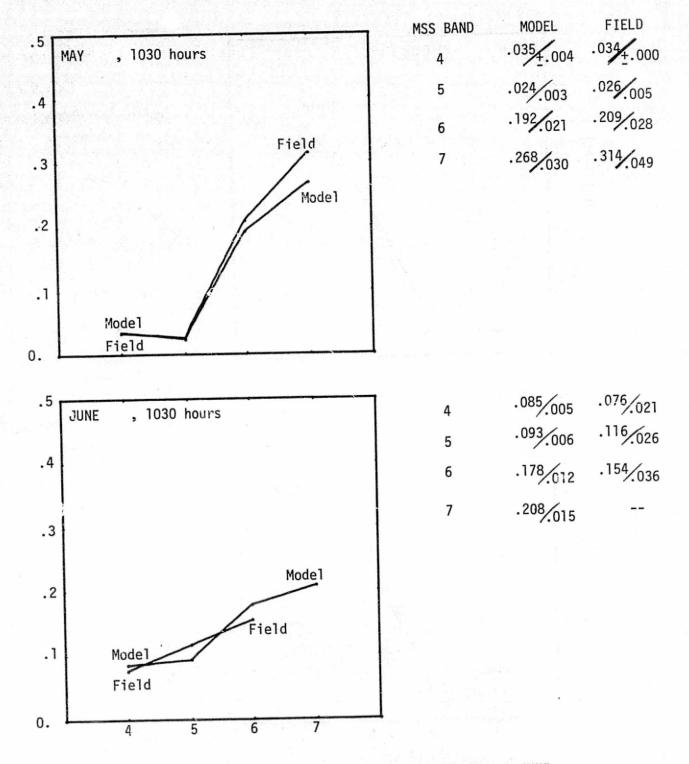


FIGURE 2. COMPARISON OF MODEL AND FIELD DATA FOR MAY AND JUNE

2.0 Summary of Sun Angle Effects

Tables 1 and 2 in Appendix C present the field measured and canopy modeled scene reflectance as a function of sun angle for each of the LANDSAT bands. In general, as the zenith solar angle increases, the canopy reflectance displays an increasing linear response until 55° zenith, then becomes monotonic. The canopy model's ability to track the empirical data throughout the linear range appears good; however, within the curvilinear region its accuracy degrades (Figures 3 and 4).

The model sun angle/reflectance data was used in developing the alpha, beta coefficient matrices required for the linear sun angle correction algorithm, previously described in Section II of this volume. The primary requirement of the data for this use is that it accurately maps the trend of the data, rather than precisely corresponding to the absolute value of individual points.

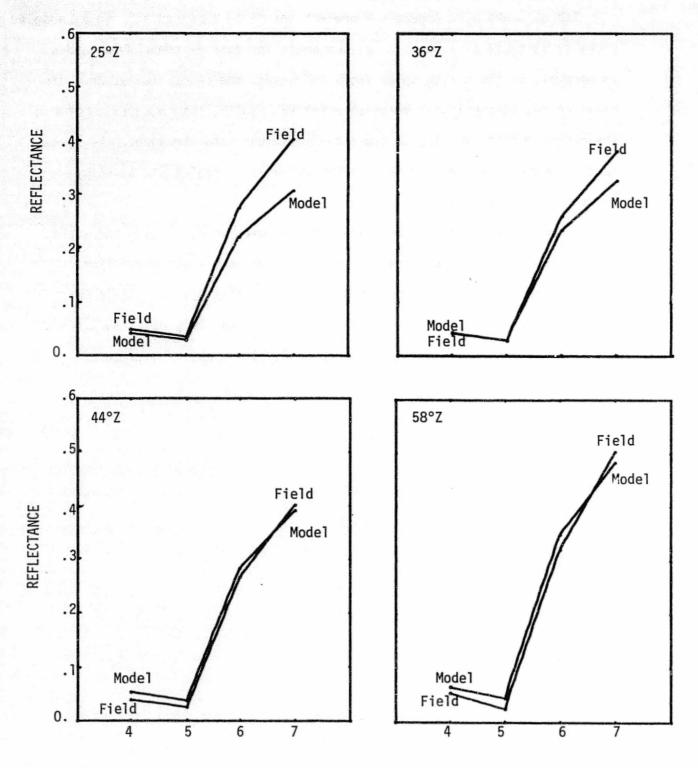


FIGURE 3. Comparison of Model and Field Data for Four Sun Angles in April.

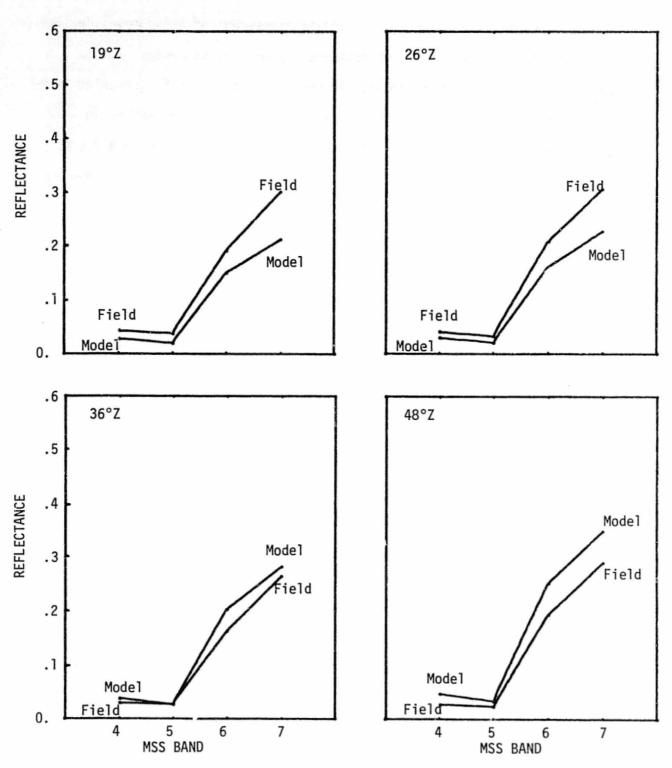


FIGURE 4. Comparison of Model and Field Data for Four Sun Angles in May

IV. INTRINSIC SCENE FEATURES

This section is an initial feasibility assessment of using model derived information to infer intrinsic characteristics of a plant canopy. It is hypothesized that, if these more stable characteristics can be decoupled from the complex scene reflectance, they could be used as feature vectors in classification. For example, a relatively high response in MSS band 7 and a low response in MSS band 4 may be indicative of high biomass, as determined from canopy modeling. The process would involve developing a series of matrices correlating scene reflectance and the intrinsic factor for expected targets, then comparing the remote sensed response with these matrices to infer the level of the intrinsic factor for each target. In the biomass example, a given sensor response may infer a large biomass for both wheat and sugar beets in mid April. However, a priori knowledge allows the dismissal of the classification of sugar beets as it is known that these fields are juvenile in April.

It is not purported that this mode of analysis would replace current methods of classification, but merely offer additional information. Its potential advantages lie in the relative stability of intrinsic characteristics and minimal demands for repetitive ground truth. In addition, once an area is classified as to scene type, an estimate of its status is readily accessible.

This preliminary study is concerned with the determination of leaf area index (LAI), an established measure of the total one-sided surface area of all plants within a unit cube. As this index increases, more dense canopies are indicated. A wheat canopy is used in the study, with the empirical measures being the same as those described in previous sections of this report, and generally presented in Section IV.1, Volume II. Due to the feasibility nature of this investigation, only the tillering (March) and jointing (April) stages

are described. This section consists of four subsections:

- a comparison of empirical and model estimated reflectance/
 LAI relationships;
- a presentation of the model predicted radiance/LAI relationships at a satellite sensor;
- 3) an evaluation of the effect of sun angle corrections to April field based radiance/LAI relationship; and
- 4) recommendations.

1.0 Comparison of Model and Field Data

Figures 1 through 4 graphically portray the relationship between scene reflectance and LAI for both the field measurements and model predictions in March and April. Tables 1 and 2 of Appendix D tabularly summarize the data. The model data for March identifies a positive relationship for MSS bands 4, 6, and 7 which appears to plateau at LAI's above 3.5. Band 5 displays a less prominent negative relationship which also approaches an asymptote at about 3.5 LAI. The model data based on April parameters shows a slight negative relationship for all four bands throughout the 3.5 to 8.5 LAI range. These general trends favorably agree with published studies of a closely related factor, canopy biomass (Pearson, 1973).

The empirical data for these same periods tend to agree with the model data, with the exception of the lowest LAI in March. This discrepancy could arise from either of two sources: 1) the model's inability to precisely respond to low LAI's of a rowed crop, or 2) an anomolous measurement. As the model has generally performed well throughout the rest of the study, the latter source is the most plausible. An overstated field reflectance measurement could easily result through the highly variable soil reflectance contribution and differing percent ground covers. Also contributing could have been the

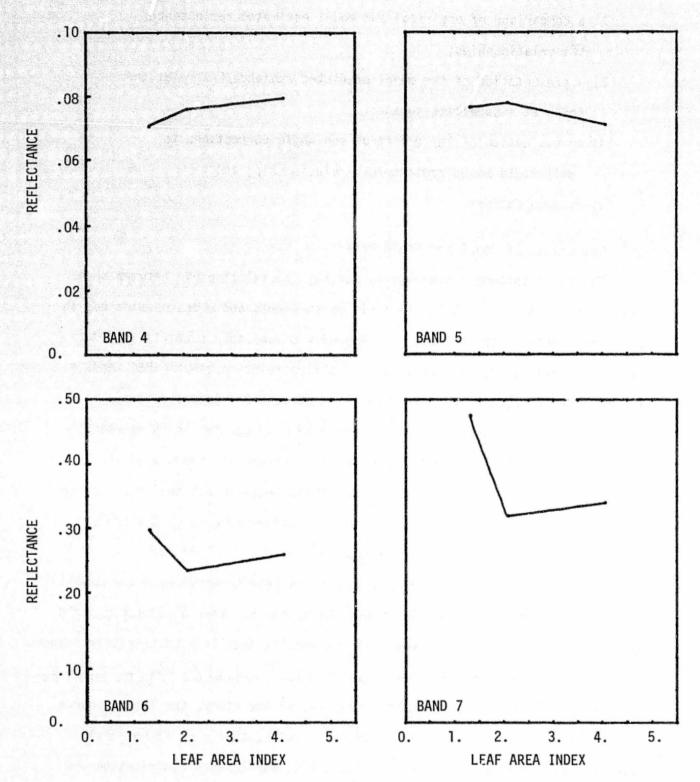


FIGURE 1. Field LAI Effects for March at Surface

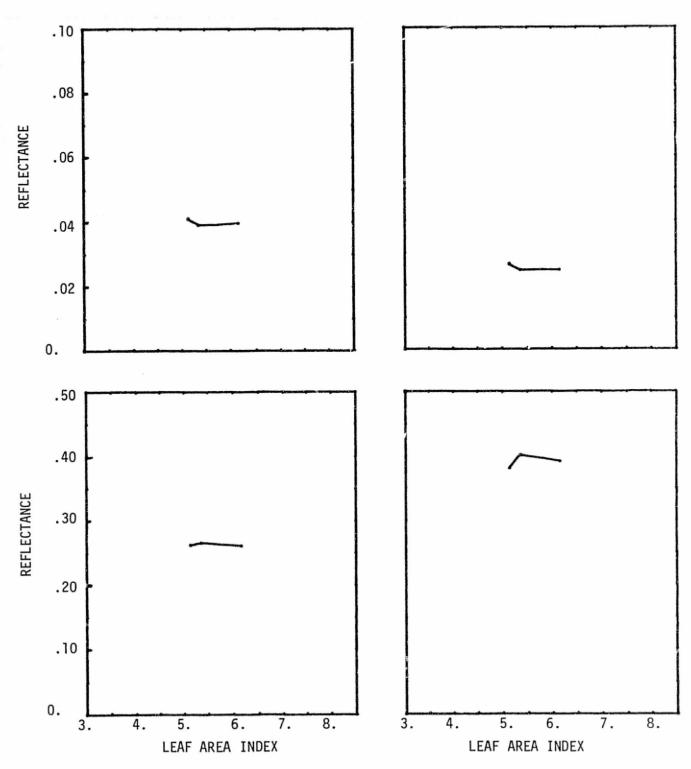


FIGURE 2. Field LAI Effects for April at Surface

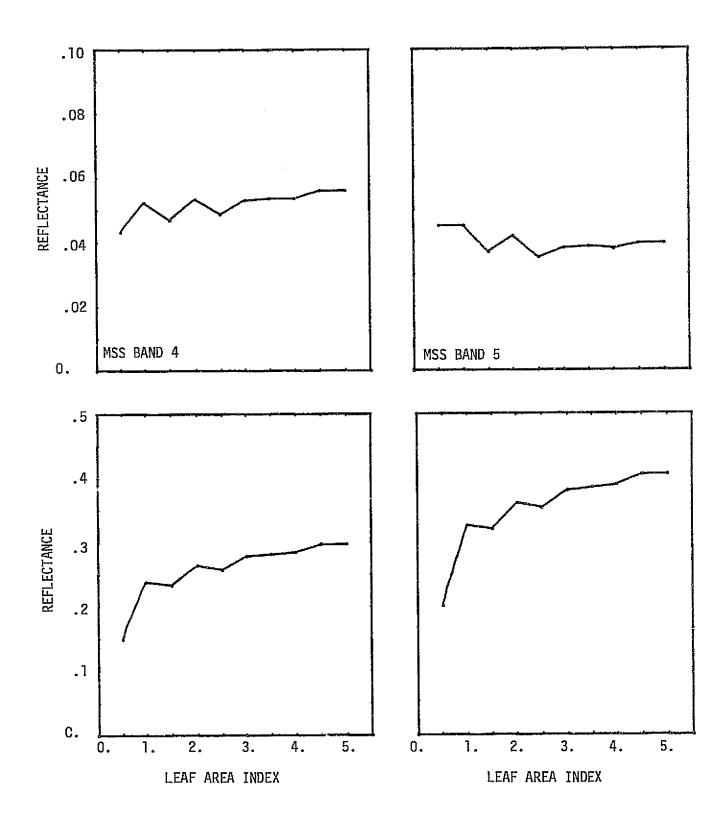


FIGURE 3. MODEL LAI EFFECTS FOR MARCH AT SURFACE

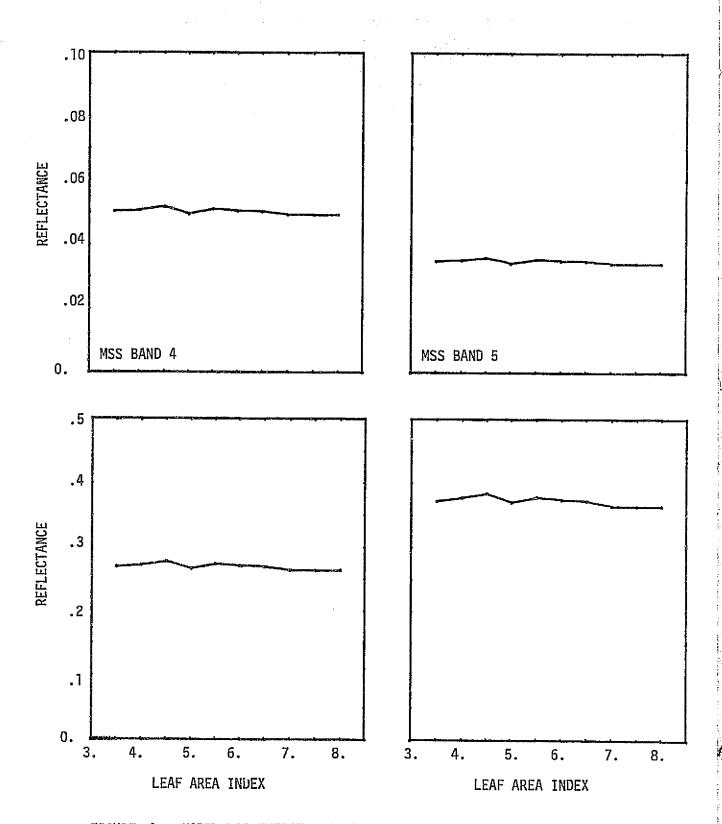


FIGURE 4. MODEL LAI EFFECTS FOR APRIL AT SURFACE

difficulties of selecting and analyzing a subplot of the larger radiometric plot for LAI determination. Past studies in this area, again, support the contention that this point is atypical.

Figure 5 shows that the reflectance ratio of the farthest infrared band (MSS7) to the chlorophyll band (MSS5) increases with plant canopy cover. This ratio has been reported as a good data transformation for assessing changes in scene vegetative biomass (Pearson, 1973), which is closely related to LAI. The characteristic increase in this ratio throughout the lower LAI's, followed by a relatively flat response of higher indices, agrees with the general results of these studies.

2.0 Model Predicted Radiance/LAI Relationship

In extending the scene reflectance/LAI analysis to simulated radiance readings at a satellite platform, the ERIM atmospheric model was utilized. A brief discussion of this procedure is dealt with in Section II of this volume. Figures 6, 7, and 8 and Table 3 of Appendix D present the results.

It is in this form that the inference of the intrinsic scene characteristic of LAI might be derived by comparing compatible sensor signals with the model derived values. This information could become part of the classification processor as an additional feature vector. The effectiveness of this approach could not be evaluated. This initial study, however, outlines a procedure and establishes an initial data set which could lend itself to evaluation.

3.0 Sun Angle Correction of the April Radiance/LAI Relationship

One of the principle attractions for using model derived intrinsic factors is the relative de-emphasis on repetitive ground truth. In order to extend the usefulness of these relationships, corrections for sun angle, a highly variable environmental factor, should be applied. Figure 9 graphically shows

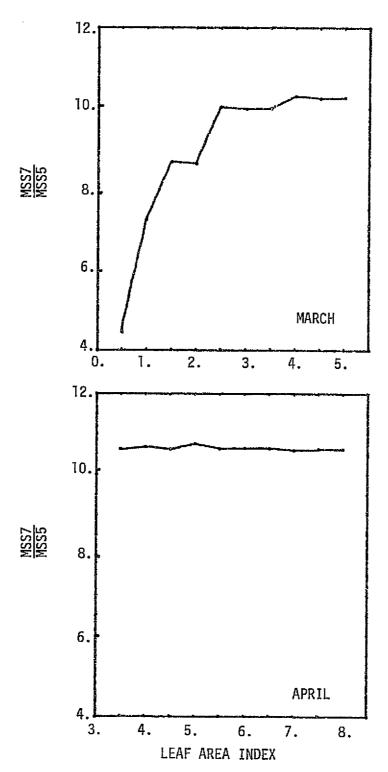


FIGURE 5. Ratio of MSS Bands 7/5
Relationship to LAI for
Model Reflectance Data
at Surface (Unsmoothed)

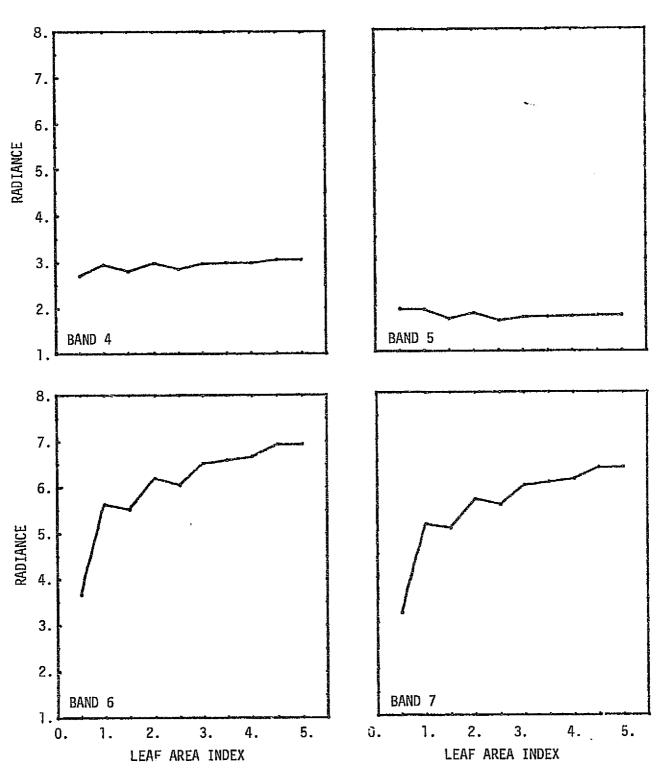


FIGURE 6. Model LAI Effects for March at Satellite (Milliwatts/Square Centimeter/Steradian/Micrometer)

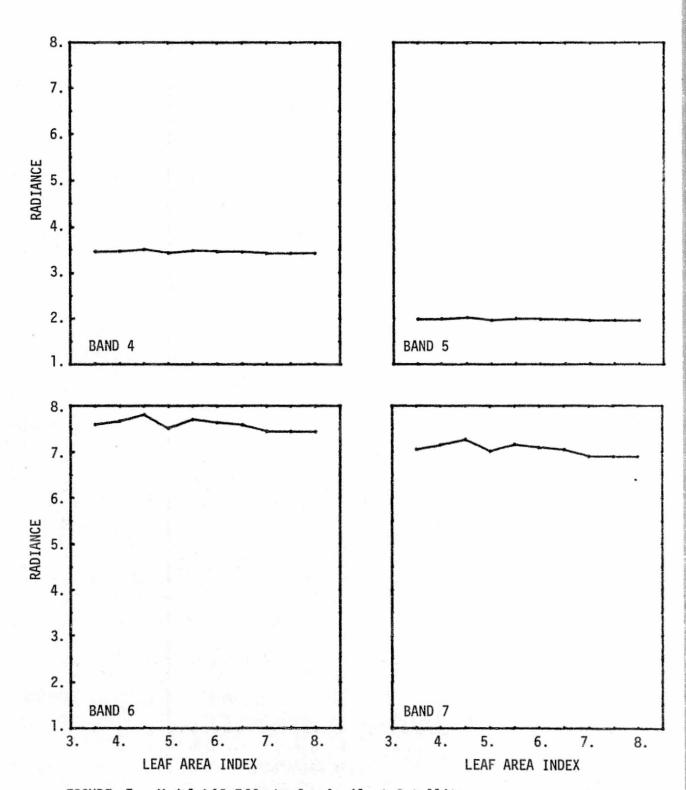


FIGURE 7. Model LAI Effects for April at Satellite (Milliwatts/Square Centimeter/Steradian/Micrometer)

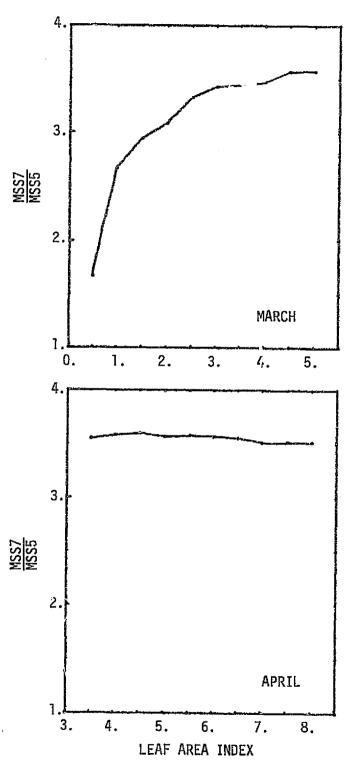


FIGURE 8. Ratio of MSS Bands 7/5
Relationship to LAI for
Model Radiance Data at
Satellite (Smoothed)

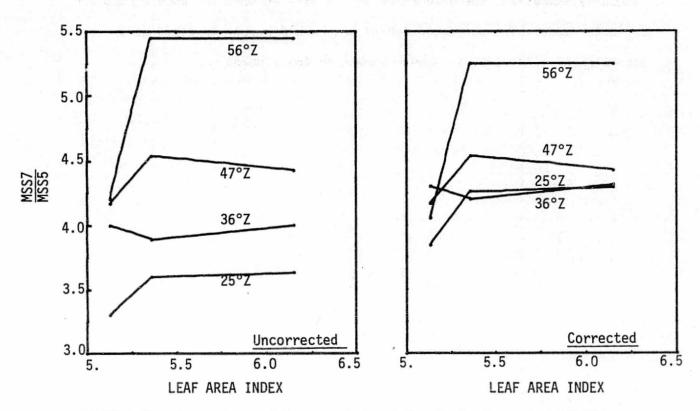


FIGURE 9. Comparison of Uncorrected and Sun Angle Corrected MSS7/5 Radiance Ratio for April

TABLE 1
MEAN AND STANDARD DEVIATION
FOR MSS7/5 RATIO IN APRIL
(Averages Over for Sun Angles)

	Uncorr	Uncorrected			
LAI	μ	ď	μ	Ø	
5.13	3.919	.420	4.092	.192	
5.36	4.369	.819	4.562	.482	
6.15	4.377	.783	4.570	.456	

the effect of correcting for sun angle on the MSS7/5 ratio in April and tabularly summarizes the dispersion of the data in both the uncorrected and corrected mode. The corrected sensor data would appear to yield more accurate LAI estimates, as demonstrated in the figure.

V. CONCLUSIONS AND RECOMMENDATIONS

The correction coefficients identified in Appendix A appear to aid in extending signatures for sun angle variation. Within a restricted zenith sun angle range of 35-50 degrees, it is empirically observed that canopy reflectance is mainly Lambertian. Further, reflectance changes with crop stage are simple shifts in scale in this sun angle range. Thus, choice of correction coefficients calculated using directional or Lambertian canopy reflectance characteristics or as a function of stage is not critical. However, at larger solar zenith angles, the coefficients display much greater variation (10-20%). Consequently, it is recommended that a consistent set of alpha/beta matrices be employed which account for both crop stage and directional reflectance properties for all sun angles. Tables IX, X, XI, XII in Appendix A are a candidate set which satisfy this criteria and could be employed in an operational test.

In this study, it was noted that sun angle variations depend on canopy characteristics. The effects of the vegetative canopy are most pronounced at the larger solar zenith angles (20 percent). The linear sun angle correction coefficients demonstrate a dependency on both crop stage (15-20 percent) and crop type (10-20 percent). A marked disparity between Stage I and Stages II, III and IV coefficients is readily apparent (difference of 15-20 percent). The effect of simulated changes in crop types is greatest for infrared bands (10-20 percent) and for wheat/barley confusion crops.

The use of canopy reflectance modeling allowed for the generation of a simulated data set over an extremely broad envelope of sun angles. In general, the canopy model was able to adequately track the empirical data, with its best estimates occurring in Bands 5 and 6. The relatively less precise pre-

dictions for Stages I and IV are most likely attributable to pronounced rowing effects and incomplete empirical data, respectively. The model is most sensitive to estimates of individual leaf reflectance and transmission. It is anticipated that the forthcoming field season will allow for an improved estimate of these parameters, and subsequent improvement in model predictions.

The use of canopy modeling to infer intrinsic canopy characteristics appears promising. A distinguishable relationship between LAI and canopy reflectance was simulated which favorably compares with empirical studies.

The 1976 field measurement program associated with this study will be basically the same as that of 1975. This continuity will allow for a terse evaluation of expected temporal variation in the canopy variables studied. It is recommended, however, that the canopy modeling field measurement emphasis be shifted from intensively describing single plots, to estimating entire fields. Specific procedural recommendations include: 1) design and construction of an attachment to the LANDSAT Field Radiometer which measures individual leaf reflectance; 2) identify a "sacred radiometric" plot which is repeatedly measured throughout the developmental stages; and 3) collect radiometric data on "clipped" plots to review soil reflectance effects in more detail.

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APPENDIX A: ALPHA AND BETA TABLES

		Page
1.0	Sun Angle Correction Coefficient Tables (Average Lambertian Reflectance)	A.1
	Table I March (35-55 Degrees) Table II April (25-60 Degrees) Table III May (20-55 Degrees) Table IV June (15-50 Degrees)	A.1 A.2 A.5 A.8
2.0	Sun Angle Correction Coefficient Tables (Average Directional Reflectance)	A.10
	Table V March (35-55 Degrees) Table VI April (25-60 Degrees) Table VII May (20-55 Degrees) Table VIII June (15-50 Degrees)	A.10 A.11 A.14 A.17
3.0	Sun Angle Correction Coefficient Tables	
	(Model Derived Canopy Reflectance)	A.19
	Table IX March (5-70 Degrees) Table X April (5-70 Degrees) Table XI May (5-70 Degrees) Table XII June (5-70 Degrees)	A.19 A.23 A.27 A.31

TABLE I. SUN ANGLE CORRECTION COEFFICIENT TABLES FOR MARCH EMPIRICAL DATA SET (AVERAGE LAMBERTIAN REFLECTANCE)

(A)	Alpha Table		
	Wavelength =	0.55	micrometers

91	θ ₂	35	40	45	50	55
35		1.00	.93	.85	.77	.68
40		-	1.00	.92	.83	.73
45		-	-	1.00	.90	.80
50		-	-	-	1.00	.88
55		-	-	-	-	1.00

(C)	Alpha Table		
	Wavelength =	0.65	micrometers

91	92	35	40	45	50	55
35		1.00	.93	.86	.78	.69
40		-	1.00	.92	.83	.74
45		-	-	1.00	.90	.80
50		-	-	-	1.00	.89
55		_	-	_	_	1.00

(E) Alpha Table
Wavelength = 0.75 micrometers

		_				
θ1	θ2	35	40	45	50	55
35		1.00	.93	.86	.78	.69
40		-	1.00	.92	.83	.74
45		-	-	1.00	.91	.81
50		-		-	1.00	.89
55		-	-	-	-	1.00

(G) Alpha Table
Wavelength = 0.95 micrometers

		9					
91	θ2	35	40	45	50	55	
35		1.00	.93	.86	.78	.70	
40		-	1.00	.92	.84	.74	
45		-	-	1.00	.91	.81	
50		-	-	-	1.00	.89	
55		-	-	-	-	1.00	

(B) Beta Table
 Wavelength = 0.55 micrometers

θ1	θ2	35	40	45	50	55
35		0.00	05	03	.00	.09
40		25	0.00	.02	.04	.13
45		-	- "	0.00	.03	.11
50		-	-	-	0.00	.09
55		-	_	-	-	0.00

(D) Beta Table
Wavelength = 0.65 micrometers

91	θ2	35	40	45	50	55	
35		0.00	03	02	00	04	
40			0.00	.01	.02	.06	
45		-	-	0.00	.01	.06	
50		-	-	-	0.00	.04	
55		-	-	_ '	-	0.00	

(F) Beta Table
Wavelength = 0.75 micrometers

θ ₁	θ2	35	40	45	50	55
35		0.00	01	01	00	.02
40		-	0.00	.00	.01	.03
45		-	-	0.00	.01	.03
50		-	-	-	0.00	.02
55		-	-	-	-	0.00

(H) Beta Table
 Wavelength = 0.95 micrometers

19	θ2	35	40	45	50	55
35		0.00	01	00	.00	.01
40		-	0.00	.00	.01	.02
45		-	-	0.00	.00	.01
50		-	-	-	0.00	.01
55		-	-	-	-	0.00

TABLE II. SUN ANGLE CORRECTION COEFFICIENT TABLES FOR APRIL EMPIRICAL DATA SET (AVERAGE LAMBERTIAN REFLECTANCE)

(A) Alpha Table		
Wavelength =	0.55	micrometers

θ1	θ2	25	30	35	40	45	50	55	60
25		1.00	.95	.90	.84	.77	.69	.61	.53
30			1.00	.94	.88	.80	.73	.64	.55
35				1.00	.93	.85	.77	.68	.59
40		-		-	1.00	.92	.83	.73	.63
45		-	-	-	-	1.00	.90	.80	.68
50		-		-			1.00	.88	.76
55		-				- 4		1.00	.86
60			r de <u>L</u> errand		-			<u>-</u>	1.00

(B) Beta Table
Wavelength = 0.55 micrometers

		3							
θ ₁	θ2	25	30	35	40	45	50	55	60
25		0.00	18	21	25	21	16	05	.05
30		-	0.00	04	09	07	03	.06	.15
35		-	1.2	0.00	05	03	.00	.09	.18
40		-	-	-	0.00	.02	.04	.13	.21
45		de -	-	90.00 -	-	0.00	.03	.11	.20
50		_		-	-	a - i-	0.00	.09	.17
55		-				-		0.00	.10
60		-	_	-		7 - 1			0.00

(C) Alpha Table
 Wavelength = 0.65 micrometers

θ ₁	θ2	25	30	35	40	45	50	55	60
25		1.00	.95	.90	.84	.77	.70	.62	.54
30			1.00	.94	.88	.81	.73	.65	.56
35				1.00	.93	.86	.78	.69	.60
40			-	-	1.00	.92	.83	.74	.64
45		-			-	1.00	.90	.80	.69
50		- L -		-	-		1.00	.89	.77
55		-		- 1	-	-	-	1.00	.87
60			_		_	-	-	100	1.00

(D)	Beta Table		
•	Wavelength =	: 0.6	55 micrometers

91	92	25	30	35	40	45	50	55	60
25		0.00	09	77	13	77	09	03	.02
30		-	0.00	02	05	04	02	.03	.07
35		-	_	0.00	03	02	.00	.04	.08
40			-	-	0.00	.01	.02	.06	.01
45		-	-	-	_	0.00	.01	.06	.10
50		-	-	•	••	-	0.00	.05	.09
55		-		-	-	-	-	0.00	.05
60	•	-	-	, -	-	••		-	0.00

(E) Alpha Table Wavelength = 0.75 micrometers

θ ₁	92	25	30	35	40	45	50	55	60
25		1.00	.95	.90	.84	.77	.70	.62	.54
30			1.00	`4	.88	.81	.74	.65	.57
35		-	-	1.00	.93	.86	.78	.69	.60
40		**	-	-	1.00	.92	.83	.74	.64
45		-	-	-	-	1.00	.97	.81	.70
50		-	-	-	-	-	1.00	.89	.77
55		-	_	_	-	-	-	1.33	.87
60		-	h	-	-	-	-	-	1.00

(F) Beta Table Wavelength = 0.75 micrometers

٦ ^Θ	θ ₂	25	30	35	40	45	50	55	60
25		0.00	05	06	07	06	05	02	.01
30		-	0.00	01	03	02	01	.01	.04
35			-	0.00	01	01	.00	.02	.05
40		-	-		0.00	.01	.01	.03	.06
45		-	-	-		0.00	.01	.03	.06
50		-	-	-	-	-	0.00	.02	.05
55		-	-		-		-	0.00	.03
60			-	-	-	-	-	-	0.00

(G) Alpha Table
Wavelength = 0.95 micrometers

91	θ ₂	25	30	35	40	45	50	55	60
25	· · · · · · · · · · · · · · · · · · ·	1.00	.96	.90	.84	.78	.71	.63	.55
30		_	1.00	.95	.88	.81	.74	.66	.57
35		. =	_	1.00	.93	.86	.78	.70	.60
40	•	·. _		-	1.00	.92	.84	.74	.65
45		-	_	·	-	1.00	.91	.81	.70
50		-		-	-	₩	1.00	.89	.77
55	* * * ** *	-	-	-	_	-	-	1.00	.87
60		•	-	-	-		- .	. •	1.00

(H) Beta Table Wavelength = 0.95 micrometers

01	⁰ 2	25	30	35	40	45	50	55	60
25		0.00	02	02	02	02	07	.00	.01
30		_	0.00	.00	01	01	.00	.01	.02
35			-	0.00	.00	.00	.00	.01	.02
40		-	-	-	0.00	.00	.01	.02	.03
45			-	-	-	0.00	.00	.01	.02
50		-	-	-	-		0.00	.01	.02
55				-	_	-	-	0.00	.01
60		_	-	-	-	-	-	-	0.00

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TABLE III. SUN ANGLE CORRECTION COEFFICIENT TABLES FOR MAY EMPIRICAL DATA SET (AVERAGE LAMBERTIAN REFLECTANCE)

		(AVERA	GE LAMBER	TIAN REFL	ECTANCE)				
(A)	Alpha T Wavelen	able gth = 0.5	55 microme	ters				e e	
97	θ2	20	25	30	35	40	45	50	55
20		1.00	.96	.92	.86	.80	.74	.67	.59
25	•	_	1.00	.95	.90	.84	.77	.69	.61
30		-	-	1.00	.94	.88	.80	.73	.64
35		-	-	_	1.00	.93	.85	.77	.68
40		-	•••	-	_	1.00	.92	.83	.73
45		-	-	-	-		1.00	.90	.80
50		-	pus.	-	-	-	-	1.00	.88
55		-	-	-	-	-	-	-	1.00
(B)	Beta Ta Waveler		55 microme	eters					
97	⁰ 2	20	25	30	35	40	45	50	55
20		0.00	14	31	34	36	32	26	14
25		-	0.00	18	27	25	21	16	06
30		-	-	0.00	04	09	07	03	.06
35		-	_	-	0.00	05	03	.00	.09
40		••	-	-	-	0.00	.02	.04	.13
45		-	-	-		-	0.00	.03	.11
50		-		_	-	-		0.00	.09
55		-	-	-	-	-	-	-	0.00
(C)	Alpha ' Wavele	Table ngth = 0.	65 microm	eters					
Θ7	⁰ 2	20	25	30	35	40	45	50	55
20		1.00	.96	.92	.87	.81	.74	.67	.60
25		_	1.00	.95	.90	.84	.77	.70	.62
30		-		1.00	.94	.88	.81	.73	.65
35		-	-	-	1.00	.93	.86	.78	.69
40		-	-	-	-	1.00	.92	.83	.74
45		-	-	-		-	1.00	.90	.80

50

55

1.00

.89

1.00

Beta Table			
Wavelength	=	0.65	micrometers

Θ ₁	9 ₂	20	25	30	35	40	45	50	55
20		0.00	07	16	17	19	17	14	08
25		**	0.00	09	11	13	11	09	04
30		⊷		0.00	02	05	04	02	.02
35		-	-	-	0.00	03	02	00	.04
40		***	_	-		0.00	.01	.02	.06
45		-	-	-	-	-	0.00	.01	.05
50		-	-	-	-	•	-	0.00	.04
55		-	-		200	-	-	-	Q.00

(E) Alpha Table Wavelength = 0.75 micrometers

9,	θ ₂	20	25	30	35	40	45	50	55
20		1.00	-96	.92	.87	.81	.75	.68	.60
25		-	1.00	.95	.90	.84	.77	.70	.62
30		-	_	1.00	.94	.88	.81	.74	.65
35			-	_	1.00	.93	.86	.78	.69
40		-	-	- .		1.00	.92	.83	.74
45		-	-		-	-	1.00	.91	.80
50		-	-	-	-	**	-	1.00	.89
55		_	-	_	-	-	-	-	1.00

(F) Beta Table Wavelength = 0.75 micrometers

97	θ2	20	25	30	35	40	45	50	55
20		0.00	04	98	09	10	09	07	04
25		***	0.00	05	06	07	06	05	02
30		-	-	0.00	01	03	02	01	.01
35		-	-	-	0.00	02	01	00	.02
40			-	-	-	0.00	.00	.07	.03
45		_	-	-		-	0.00	.01	.03
50		-	-	_	-	•••	-	0.00	.02
55		-	-	-	-	-	-	-	0.00

(G) Alpha Table Wavelength = 0.95 micrometers

θŢ	⁰ 2	20	25	30	35	40	45	50	55
20		1.00	.96	.92	.87	.81	.75	.68	.61
25		-	1.00	.95	.90	.84	.78	.70	.63
30		-	-	1.00	.95	.88	.81	.74	.66
35		-	-	-	1.00	.93	.86	.78	.70
40		-	-	-	_	1.00	.92	.84	.74
45		-	-	_	-	-	1.00	.91	.81
50		•••	-	-	-	-	-	1.00	.39
55		-	-	-		-	-	-	1.00

(H) Beta Table
 Wavelength = 0.95 micrometers

91	⁰ 2	20	25	30	35	40	45	50	55
20		0.00	01	03	03	03	03	02	01
25		-	0.00	02	02	02	02	01	.00
30		-	-	0.00	01	01	01	.00	.01
35		-	_	_	0.00	01	.00	.00	.01
40		-	-	-	-	0.00	.00	.00	.02
45		-	-	-	-	_	0.00	.00	.01
50		-	-	-	-	-	-	0.00	.01
55		**	-	-	-	-	-	-	0.00

TABLE IV. SUN ANGLE CORRECTION COEFFICIENT TABLES FOR JUNE EMPIRICAL DATA SET (AVERAGE LAMBERTIAN REFLECTANCE)

(A)	Alpha Table		
	Wavelength =	0.55	micrometers

97	θ2	75	20	25	30	35	40	45	50
15		1.00	.97	.93	.89	.84	.78	.72	.65
20		-	1.00	.96	.92	.86	.80	.74	.67
25		-	~	1.00	.95	.90	.84	.77	.69
30		-	-	.	1.00	.94	.88	.81	.73
35		-	•••	-	-	7.00	.93	.85	.77
40			-	-		-	1.00	.92	.83
45		~	-	A *	_	-	-	1.00	.90
50		_	-	-	-	-	***	-	1.00

(B) Beta Table Wavelength = 0.55 micrometers

91	θ ₂	15	20	25	30	35	40	45	50
15		0.00	33	45	62	62	63	56	48
20		-	0.00	14	31	34	36	32	26
25		-	•••	0.00	18	21	25	21	16
30		-	-		0.00	04	09	07	03
35			-	-	-	0.00	05	03	.00
40		-	-	-	-	-	0.00	.02	.04
45		-	-	-	-	~	-	0.00	.03
50		⊷		_	~		-	_	0.00

(C) Alpha Table Wavelength = 0.65 micrometers

97	θ2	15	20	25	30	35	40	45	50
15		1.00	.97	.94	.89	.84	. 79	.72	.65
20		***	1.00	.96	.92	.87	.81	.74	.67
25		***	-	1.00	.95	.90	.84	.77	.70
30		-	-	-	1.00	.94	.88	.81	.73
35		-	-		-	1.00	.93	.86	.78
40		-	-	-	~	-	1.00	.92	.83
45		-	-	••	••	-		1.00	.90
50		we we	-	-	VII.	-	-		1.00

(D)	Beta Table			
	Wavelength	=	0.65	micrometers

97	θ ₂	15	20	25	30	35	40	45	50
15		0.00	15	21	29	30	31	28	24
20		-	0.00	07	16	17	19	17	14
25		-	-	0.00	09	11	13	11	09
30		-	-	-	0.00	02	05	04	02
35		-	-		-	0.00	03	09	.00
40		-	-	-	-	-	0.00	.01	.02
45		-	-	-	-	-	-	0.00	.01
50		-	-	-	-	-	-	-	0.00

(E) Alpha Table Wavelength = 0.75 micrometers

θ1	92	15	20	25	30	35	40	45	50
15		1.00	. 37	.94	.89	.84	.79	.73	.66
20		-	1.00	.96	.92	.87	.81	.75	.68
25		-	-	1.00	.95	.90	.84	.77	.70
30		-	-	-	1.00	.94	.88	.81	.74
35		-	-	-	-	1.00	.93	.86	.78
40		-	-	-	-	-	1.00	.92	.83
45		-	-	-	-	_	-	1.00	.91
50		-	-	-	-	-	-	-	1.00

(F) Beta Table Wavelength = 0.75 micrometers

91	θ2	15	20	25	30	35	40	45	50
15		0.00	07	10	15	15	15	14	12
20		***	0.00	04	08	09	10	09	07
25		-		0.00	05	06	07	06	05
30		-	***	-	0.00	01	03	02	01
35		-	-	-	_	0.00	01	01	.00
40		_	-	-	-	-	0.00	.00	.00
45		-	-	-	-	-	-	0.00	.00
50		-	-	-	-	-	-	-	0.00

TABLE V. SUN ANGLE CORRECTION COEFFICIENT TABLES FOR MARCH EMPIRICAL DATA SET (AVERAGE DIRECTIONAL REFLECTANCE)

1.00

(A)	Alph Wave	na Tabl elength	e = 0.5	5 micr	ometers	5
91	θ2	35	40	45	50	55
35		1.00	.98	.93	.87	.79
40			1.00	.95	.89	.81
45		-	-	1.00	.94	.86
50			· _	-	1.00	.91

(B)	Beta Table			
	Wavelength	=	0.55	micrometers

θ1	92	35	40	45	50	55
35		0.00	14	17	20	14
40		-	0.00	04	07	02
45		-	_	0.00	04	.01
50		-	-	***	0.00	.05
55		_	_	-	_	0.00

(C)	Alpha Table		
	Wavelength =	0.65	micrometers

55

	nu v c	. i chigon	0.0	- 111101	Olife act	J
91	92	35	40	45	50	55
35		1.00	1.02	1.04	1.00	.95
40		-	1.00	1.02	.98	.93
45		-	-	1.00	.96	.91
50		-	_	-	1.00	.95
55		-	-	-	-	1.00

	Beta Table			
•	Wavelength	=	0.65	micrometers

91	⁰ 2_	35	40	45	50	55
35		0.00	11	20	23	22
40		-	0.00	09	12	17
45		-		0.00	03	03
50		-	-	-	0.00	.00
55			-	-		0.00

(E)	Alpha Table		
	Wavelength =	0.75	micrometers

97	⁰ 2	35	40	45	50	55
35		1.00	.98	.94	.88	.81
40		-	1.00	.95	.90	.83
45		-	-	1.00	.94	.87
50		-	-	-	1.00	.92
55		-	-	-	-	1.00

(F) Beta Table
 Wavelength = 0.75 micrometers

97	⁹ 2_	35	40	45	50	55
35		0.00	04	05	06	04
40		-	0.00	07	02	01
45		-	-	0.00	01	.00
50		-		-	0.00	.01
55		_		-	-	0.00

(G)	Alpha Table		
	Wavelength =	0.95	micrometers

						_
βŢ	θ2	35	40	45	50	55
35		1.00	.96	.90	.83	.76
40		-	1.00	.94	.87	.80
45		-	-	1.00	.92	.85
50		-	-	-	1.00	.92
55		-	-	_	-	1.00

91	⁰ 2	35	40	45	50	55
35		0.00	01	01	01	.00
40		-	0.00	.00	.00	.01
45		-		0.00	.00	.01
50		-		-	0.00	.01
55		-		-	_	0.00

TABLE VI. SUN ANGLE CORRECTION COEFFICIENT TABLES FOR APRIL EMPIRICAL DATA SET (AVERAGE DIRECTIONAL REFLECTANCE)

(A)	Alpha Table		
()	Wavelength =	0.55	micrometers

θ,	⁰ 2	25	30	35	40	45	50	55	60
25		1.00	.90	.78	.68	.59	.53	.49	.51
30		-	1.00	.86	.75	.66	.59	.55	.56
35		_	_	1.00	.87	.76	.69	.63	.65
40		_	-	_	1.00	.87	.79	.73	.74
45		_	-	-	-	1.00	.90	.84	.85
50		-	_	-	-	-	1.00	.93	.94
55		-	-			-	-	1.00	1.02
60		-	-	-	-	-	-	-	1.00

(B) Beta Table Wavelength = 0.55 micrometers

θ,	92	25	30	35	40	45	50	55	60
25		0.00	05	.08	.14	.22	.23	.23	.10
30		_	0.00	.12	.18	.25	. 25	.25	.13
35				0.00	.07	.15	.17	.18	.05
40		_	-	-	0.00	.09	.11	.12	.00
45		-	-	_	-	0.00	.03	.05	08
50		<u></u>	***	_	-	-	0.00	.02	11
55		<u></u>	-		-	_	-	0.00	13
60			-	-	-		-	-	0.00

(C) Alpha Table Wavelength = 0.65 micrometers

_		ingen = o.e		35	40	45	50	55	60
97	θ ₂	25	30						
25		1.00	.91	.81	.68	. 58	.49	.38	.30
30			1.00	.89	.74	.64	.54	.42	.33
35		_	-	1.00	.83	.72	.61	.46	.37
40		_	_	-	1.00	.86	.73	.56	.44
45		_	→		-	1.00	.85	.65	.51
			_		_	_	1.00	.76	.61
50		-			_	_	-	1.00	.80
55		-	-	-					1.00
60			-	***	-	-	-	-	1.00

April - Directional

								April -	Direction
(D)			65 microm	eters					
97	θ ₂	25	30	35	40	45	50	55	60
25		0.00	03	.00	.07	.12	.16	.26	.31
30		-	0.00	.03	.10	.14	.18	.28	.32
35		-	-	0.00	.07	.12	.17	.27	.31
40		-	-	-	0.00	.06	.17	.22	.28
45		-	- .	-	-	0.00	.06	.19	.25
50		-	-	-	-		0.00	.14	.21
55			-	-		-	-	0.00	.10
60			••	-		-	-	-	0.00
(E)	Alpha T Wavelen		75 microm	eters					
97	92	25	30	35	40	45	50	55	60
25	-	1.00	.95	.88	.82	.75	.68	.62	.66
30		-	1.00	.93	.86	.79	.72	.66	.69
35		-	-	1.00	.93	.85	.77	.71	.74
40		-	-		1.00	.92	.83	.76	.80
45			-		-	1.00	.91	.83	.87
50		←	=	-	-	-	1.00	.91	.96
55		***	=	-	-	=	-	1.00	1.05
60		-	-	-	6 1	=	-	-	1.00
(F)			75 microme	eters					
61	θ ₂	25	30	35	40	45	50	55	60
25		0.00	04	05	05	04	03	02	01
30		-	0.00	01	02	01	.00	.01	03
35		-	-	0.00	01	.00	.00	.02	~.03
40		-	-	-	0.00	.01	.01	.03	02
45		-	-	-	-	0.00	.01	.02	02
50		-	-	-	**	-	0.00	.01	03
55		-	-	979	-	-	-	0.00	05
60		-	-	***	-	-		-	0.00

(G) Alpha Table Wavelength = 0.95 micrometers

<u>θ</u> 1	92	25	30	35	40	45	50	55	60
25		1.00	.94	.88	.82	.75	.69	.64	.68
30		-	1.00	.93	.86	.79	.73	.68	.72
35		-	-	7.00	.93	.85	.78	.73	. 77
40			-	-	1.00	.92	.84	.79	.83
45		· -	-	-	-	1.00	.92	.86	.91
50		· -	-	-	-	-	1.00	.94	.99
55		-		-			_	1.00	1.06
60		-	_	-	-	-	-	_	1.00

97	θ ₂	25	30	35	40	45	50	55	60
25		0.00	01	01	02	01	01	01	02
30		-	0.00	-00	01	.00	.00	.00	07
35		-	-	0.00	.00	.00	.00	.00	01
40		-	-	-	0.00	.00	.00	.01	01
45		-	-	-	-	0.00	.00	.01	01
50		-	-	-	-	-	0.00	.00	01
55		-	-	-	-	-	-	0.00	01
60		-	400	-		-	_	_	0.00

TABLE VII. SUN ANGLE CORRECTION COEFFICIENT TABLES FOR MAY EMPIRICAL DATA SET (AVERAGE DIRECTIONAL REFLECTANCE)

(A)	Alpha Table		
	Wavelength =	0.55	micrometers

0 ₇	92	20	25	30	35	40	45	50	55
20	 -	1.00	.90	.83	.73	.65	.56	.48	.39
25		-	1.00	.91	.81	.72	.62	.53	.44
30		•	-	1.00	.90	.79	.69	.58	.48
35		-		-	1.00	.88	.76	.65	.54
40		-	-		-	1.00	.87	.74	.61
45		-		-	-	-	1.00	.85	.70
50			-	-	-	-	-	1.00	.83
55			-	-	=-	_	-	-	1.00

(B) Beta Table Wavelength = 0.55 micrometers

βŢ	θ2	20	25	30	35	40	45	50	55
20		0.00	.03	04	.02	.06	.16	.25	.30
25		-	0.00	07	01	.04	.14	.23	.36
30		-	-	0.00	.06	.10	.19	.28	.40
35		-	-	***	0.00	.04	.14	.24	.37
40		-	-			0.00	.11	.20	.34
45		-		-	-	-	0.00	.12	.27
50		-	-	_	-	-	-	0.00	.17
55		-	**	_	-	_	_	-	0.00

(C) Alpha Table
Wavelength = 0.65 micrometers

91	θ ₂	20	25	30	35	40	45	50	55
20	-	1.00	.87	.78	.68	.57	.49	.38	.30
25		-	1.00	.90	.78	.66	.56	.43	.35
30		-		1.00	.86	.73	.62	.48	. 39
35		-	-	-	1.00	.84	.72	.56	.45
40		-	-	-		1.00	.86	.66	.53
45			-	-	-	-	1.00	.77	.62
50		-	-	-	-		-	1.00	.81
55		-	-	-	-	-	-	-	1.00

(D)	Beta Ta Wavelen		55 microme	eters					
θ,	92	20	25	30	35	40	45	50	55
20		0.00	.06	.02	.09	.13	.18	.26	.32
25		-	0.00	03	.04	.09	.15	.24	.30
30			••	0.00	.06	.12	.16	.25	.31
35		-	-	-	0.00	.06	.17	.22	.28
40		_	-		-	0.00	.06	.18	.25
45		~	~		_		0.00	.13	.21
50			-	_	_	-	-	0.00	.10
55		-	-	-	-	-	-	-	0.00
		gth = 0.7	75 microme		25	40	a E	EO	C C
9 η	θ ₂	20	25	30	35 	40	45	50	55
20		1.00	.94	.88	.81	.74	.66	.59	.51
25		-	1.00	.93	.86	.78	.71	.62	.54
30		-	-	1.00	.92	.84	.76	.67	. 58
35		-	-	-	1.00	.91	.82	.73	.63
40		-	-	-	-	1.00	.90	.80	.70
45		-	-			-	1.00	.88	.77
50			-	-	t-a	-	-	1.00	.87
55		***	-	-	-	-	-	-	1.00
		igth = 0.	75 micromo						
93	θ2	20	25	30	35	40	45	50	55
20		0.00	02	05	05	05	03	01	.03
25		-	0.00	03	03	03	01	.01	.04
30		_	-	0.00	.00	.00	.01	.03	.06
35		-	-	***	0.00	.00	.01	.03	.06
40		-	-	-	-	0.00	.01	.03	.06
45		-			-	-	0.00	.02	.05
50		-	-	-	-	-	-	0.00	.03
55		-	-		-	-	-	~	0.00

(G) Alpha Table
Wavelength = 0.95 micrometers

97	θ_2	20	25	30	35	40	45 —————	50	55
20	 	1.00	.95	.90	.83	.77	.70	.63	.55
25		-	1.00	.94	.88	.81	.74	.66	.58
30		_	-	1.00	.93	.86	.78	.70	.61
35			-	-	1.00	.92	.84	.75	.66
40		-	-		-	1.00	.91	.81	.71
45		-	_	-		-	1.00	.90	.79
50		-	-	-	•••	-	-	1.00	.88
55		_	-	-	***	-	-	-	1.00

(H) Beta Table Wavelength = 0.95 micrometers

Θ ₇	92	20	25	30	35	40	45	50 	55
20		0.00	01	02	02	02	02	01	.01
25		_	0.00	07	01	02	01	.00	.01
30		-	-	0.00	.00	01	.00	.01	.02
35		-	-	-	0.00	.00	.00	.01	.02
40		_	-	-	-	0.00	.00	.01	.02
45		_	_	· _	-	-	0.00	.01	.02
50		•••	-	-	-	-	-	0.00	.01
55		-	-	-	-	-	-	-	0.00

TABLE VIII. SUN ANGLE CORRECTION COEFFICIENT TABLES FOR JUNE EMPIRICAL DATA SET (AVERAGE DIRECTIONAL REFLECTANCE)

(A)	Alpha Table		
_	Wavelength =	0.55	micrometers

٦ ⁰	92	15	20	25	30	35	40	45	50
15		1.00	.94	.87	.79	.73	.65	.56	.49
20		-	1.00	.93	.84	.78	.69	.60	.52
25		-	-	1.00	.91	.84	.74	.64	.56
30		-	-	-	1.00	.92	.81	.71	.62
35		-	-	-	-	1.00	.88	.77	.67
40				_	-	-	1.00	.87	.76
45		-	-	-	-	-		1.00	.88.
50		-	-	-	-	-	-		1.00

(B) Beta Table Wavelength = 0.55 micrometers

97	92	15	20	25	30	35	40	45	50
15		0.00	23	27	37	28	21	08	.00
20		-	0.00	05	12	10	05	.06	.12
25		-	-	0.00	07	06	01	.09	.15
30			-		0.00	.03	.05	.14	.20
35		-	-	-	-	0.00	.04	.14	.19
40		-	-	_	_	-	0.00	.10	.16
45		-		-	-		-	0.00	.07
50		-	-	-	_	-	-	***	0.00

(C) Alpha Table Wavelength = 0.65 micrometers

ρ _γ	⁰ 2	15	20	25	30	35	40	45	50
15		1.00	.96	.89	.78	.72	.70	.70	.64
20			1.00	.93	.82	.76	.73	.73	.67
25		-	-	1.00	.88	.81	.79	.79	.72
30		-	-	-	1.00	.92	.90	.89	.82
35		_	-		-	1.00	.97	.97	.89
40		-	-		-	-	1.00	.98	.92
45		-		-	-	-	-	1.00	.92
50		-	-		-	-	-	-	1.00

(D)	Beta Ta		55 microme	*one					
r ⁰	9 ₂	15 TS	20	25	30	35	40	45	50
15		0.00	12	74	12	11	18	24	22
20		-	0.00	02	02	02	09	15	14
25		. ••		0.00	.00	.00	07	13	12
30		_	-	•	0.00	.00	~.07	13	12
35		, -	·		••	0.00	06	13	12
40		- ·	_	-	-	-	0.00	06	06
45		-	_	-	-	-	-	0.00	.00
50		-	-	-	-	-	-	-	0.00
(E)	Alpha Wavele	Table ngth = 0.1	75 microme	eters					
Θ ₁	92	15	20	25	30	35	40	45	50
15		1.00	.96	.92	.87	.82	.75	.69	.61
20		-	1.00	.96	.91	.85	.78	.71	.64
25		-		1.00	.95	.89	.81	.74	.67
30		-	-	-	1.00	.94	.86	.79	.70
35			-	₩.	-	1.00	.91	.84	.75
40		-	-	· _	-	-	1.00	.91	.82
45			-	-		-	-	1.00	.89
50		Trail	-			-	-	-	00.1
(F)		ngth = 0.	75 micromo						* •
91	θ ₂	15 	20	25	30	35 	40	45 	50
15		0.00	06	09	13	13	12	10	08
20			0.00	03	07	08	08	06	04

91	θ ₂	15	20	25	30	35	40	45 	50
15		0.00	06	09	13	13	12	10	08
20		-	0.00	03	07	08	08	06	04
25		•	-	0.00	04	05	05	04	02
30			_		0.00	01	01	01	.01
35		-	-	-	-	0.00	01	.00	.01
40		-	-	-	-	-	0.00	.01	.02
45		-	-	-	-	_	-	0.00	.01
50		-	-	~	-	-	-	**	0.00

2.35

1.77 1.25

44	#####################################	10.	15.	20.	25. *****	.0E	35.	40 = 0 = = 0 = a	45.	50.	55.	60.	65.	70.		
5.0	1.00	1.02	1.04	1.11	1.16	1.20	1.19	1.19	1.17	1-10	1.05	1-11	1.03	• 9 3		
0.0	-98	1.00	1.01	1.08	1.14	1.17	1.16	1.16	1.1.	1.07	1.02	1.08	1.01	•91		
15	•96	. 99	1.00	1 • 07	1.12	1-16	1-15	_1.15	_1,12_	1_06_	1.01	1 - 0.7	99	90		
20.	•90	•92	.94	1.00	1.05	1+08	1.07	1.07	1.05	•99	•95	1.00	.93	.8+	•	
5.0	•86	• 68	.89	•95	1.00	1.03	1.02	1.02	1.00	•94	•90	95	.89	•8D		
30.*	-83	- 85	.86	•92	.97	1.00	•99	.99	9."_	91_	.87	.92	86_	.78		
5.4	•84	.86	.87	•93	•98	1.01	1.00	1.00	•9#	+92	•88	•93	.87	.78	•	
. g. to	6:	-88	.87	•93	.98	1.01	1.00	1.00	.98	-92	-88	•93	. B7	.79		
5.0	•86	-88	.89	•95	1.00	1.03	1.02	1.02	1.00	-94	•90	•95	8	<u>.8g</u>		 ,
0.0	•91	.93	.95	1.01	1.06	1+10	1.09	1.08	1.0h	1.00	.96	1.01	.94	.85		
5.6	95	- 98	.99	1.06	1.11	1.15	1.14	1.13	1.1:	1.05	1.00	1.06	.98	.89		
0.	- 30	. 92	.94	1.00	1.05	1 - 09	1.08	1.07	1,05	.99	•95	1.00	23	<u> </u>		
٠,٠	.97	•99	1.01	1.07	1.13	1=17	1.15	1.15	1.15	1.06	1.02	1.07	1.00	•91		
7.R	1.07						 _									
	****	1.10	1.11	1-19	1.25	1.29	1.27	1.27	1.25	1.17	1.12	1-18	1.10	1.06		
ያ ዴ ችል።	TABLE	. 	1.11	1-19	1.25	1127	1.27	1.67	1.25	1.17	1.12	1.18	1.10	1.00		
IETA'''		 55		<u></u>		· · · · · · · · · · · · · · · · · · ·						···				
327 <i>6</i> 472 <u>1</u> 2	TABLE .	55 10. 2000	15.	20. 20.	25. Vaposo	30.	35.	40 e #6 e q 0 p e	45. 242001	50.	55. 494444	···	65. 664444	70.		
S. s	TABLE Secondary Secondary	55 10. 2000	15.	20. 20.	25. *******	30.	35. 6664666 ~3.44	40. sossesse ⇔3.63	45. 248001	50. 00##0000 -3.47	55. 49**** *3.34	60 <u>.</u>	65. ************************************	70. ******		
5.0 10.4	316aT 9. = M1dW 5. 9.00	55 10. 	15. ************************************	20. ******* ~2.36	25. *******	30. *******	35. 568866 ~3.44 ~2.30	40. #800008# ₩3.63 =2.48	45. -3.65	50. -3.47 -2.42	55. ###### #3.34 #2.33	60. -3.71	65. ********* -3.43 -2.43	70. ***** -3.05 -2.15		
5.0 10.0	TABLE NGTM= .: 5. 60.00 .96	55 10. 	15. ************************************	20. ******* **2.36	25. ******** -2.86	30. ******** -3.33	35. 568866 ~3.44 ~2.30	40. #800008# ₩3.63 =2.48	45. 2000.4 -3.65 -2.5:	50. -3.47 -2.42	55. 49***** -3.34 -2.33	60. ********** -3.71	65. ********* -3.43 -2.43	70. ***** -3.05 -2.15		
5.0 10.0	TABLE	55 10. 10. 10. 10. 10. 10. 10. 10. 10. 10.	15. -1.62 62	20. 0****** -2.36 -1.30	25. ************************************	30. ******* -3.33 -2.17	35. ******* **3.44 **2.30	40. 800008 -3.63 -2.48	45. 2000.4 -3.65 -2.5:	50. 04*2029 -3.47 -2.42	55. 49***** -3.34 -2.33	60. ************************************	65. -3.43 -2.43	70. ***** -3.05 -2.15		
4751E	TABLE	55 10. 10. 10. 10. 10. 10. 10. 10. 10.	15. -1.62 62 0.00	20. 	25. ************************************	30. ******** -3.33 -2.17 -1.45	35. 6669000 -3.44 -2.30 -1.59 90	40. 9009099 93.63 -2.48 -1.77 -1.09	-3.65 -2.5: -1.8:	50. -3.47 -2.42 -1.76	55. ******* ~3.34 ~2.33 ~1.71	60. -3.71 -2.65 -1.99	65. -3.43 -2.43 -1.82	70		
5.0 10.0 13.8 20.0	TABLE NUME .: 5. 60.00 .96 1.56 2.13	55 10. 	15. ************************************	20. 0+40*** -2-36 -1-30 64 0-00	25. -2.86 -1.74 -1.04 38	30. -3.33 -2.17 -1.45 76	35. ******** *3.44 *2.30 -1.59 *.90 *.5p	40. \$00000000 ≈3.63 -2.48 -1.77 -1.09 71	45. 24964. -3.6t -2.5: -1.6: -1.7:	50. -3.47 -2.42 -1.76 -1.13	55. ******* ~3.34 ~2.33 ~1.71 ~1.11	60. 	65. -3.43 -2.43 -1.82 -1.23	703.05 -2.15 -1.59 -1.0675		
5.0 10.0 15.8 20.0 25.0 35.0	TABLE 5. 65440497 0.00 96		15. *1.62 62 0.00 .59	20. 0+00000 -2.36 -1.30 64 0.00 .36	25. ******** -2.86 -1.74 -1.04 38 0.00	30. 886*888 -3.33 -2.17 -1.457638	35. ####################################	40. \$0000000 *3.63 -2.48 -1.77 -1.09 71 33	-3,65 -2,5: -1,8: -1,1' -,7:	50. 00000000000000000000000000000000000	55. ******* *3.36 *2.33 -1.71 -1.11 *.77	60. 0***********************************	65, -3,63 -2,43 -1,82 -1,23 -,89	70. ***** -3.05 -2.15 -1.59 *1.0675		
5.0 10.0 15.8 20.0 25.0 35.0	TABLE NUME :: 5. 40.00 .96 1.56 2.13 2.45 2.77 2.89	55 10. 98 0.00 -51 1.20 1.53 1.95	15. -1.62 62 0.00 .59 .93	20. c++c++> -2.36 -1.30 64 0.00 .36 .70	25. -2.86 -1.74 -1.04 38 0.00	303.33 -2.17 -1.457638	35. -3.44 -2.30 -1.59 90 52	40. -3.63 -2.48 -1.77 -1.09 71 33	-3.65 -2.55. -1.86. -1.1' 70 4;!	-3.47 -2.42 -1.76 -1.13 78	55. ***********************************	-3.71 -2.65 -1.99 -1.35 99	65, -3,43 -2,43 -1,82 -1,23 -,89 -,57 -,44	70. 0***** -3.05 -2.15 -1.59 -1.06754635		
5. 10.0 15.8 20.0 25.0 35.0	TABLE NOTH: .: 5. 4040497 0.00 .96 1.56 2.13 2.45 2.77 2.89 3.05	55 10. 2005 2005 2005 2005 2005 2005 2005 20	15. *1.62 62 0.00 .59 .93 1.25 1.39	20. 0+00000 -2-36 -1-30	25. -2.86 -1.74 -1.04 38 0.00 .36 .51	303.33 -2.17 -1.457638 0.00 .15	35. 86689040 -3.44 -2.30 -1.59 90 52 15	40. ⇒3.63 -2.48 -1.77 -1.09 71 33 19	-3,65 -2,51 -1,66 -1,1' -,70 -,41 -,21	-3.47 -2.42 -1.76 -1.13 78 43 30	55. ******* *3.34 *2.33 -1.71 -1.11 *.77 *.44 *.31	603.71 -2.65 -1.99 -1.3599 -0.51	-3,43 -2,43 -1.82 -1.23 89 57 44	70. c***** -3.05 -2.15 -1.59 -1.06754635		
5.0 10.0 15.8 20.0 25.0 30.0 40.0	TABLE NOTH: 5. 600490497 0.00 .96 1.56 2.13 2.45 2.77 2.89 3.05	10. 10. 10. 10. 10. 10. 10. 10.	15. -1.62 62 0.00 .59 .93 1.25 1.38 1.55	20. 0+00000 -2.36 -1.3064 0.00 .36 .70 .84 1.02	25. ************************************	30. 886*888 -3.33 -2.17 -1.457638 0.00 .15 .34	35. \$668866 *3.44 *2.30 -1.59 90 *.55 *.15 0.00 .19	-3.63 -2.48 -1.77 -1.09 71 33 19	-3.65 -2.55. -1.86. -1.1' 70 46. 26.	-3.47 -2.42 -1.76 -1.13 78 43 30	55. ******** -3.36 -2.33 -1.71 -1.11 77 44 31 15	60. 0***********************************	65. -3.63 -2.43 -1.82 -1.23 89 57 44 28	70. ***** -3.05 -2.15 -1.59 *1.0675463520		

• 15

	5.	10.	15.	20.	25.	30.	35.	40 e	45.	50.	55. ******	60. ******	65. *****	70. *****	
٠	1.06	. 99	.97	1.07	1.11	1.14	1.15	1.14	1.11	1.01	197	1.04	•96	.88	
	1.01	1.00	.98	1.68	1.13	1.15	1.16	1.16	1.13	1.02	.98	1.05	.97	.89	
						1.18	1.19	1.18	1.15	1.04	1.00	1.07	.99	.91	
•	1.03	1.02	1.00	1.10	1.15									.82	
. a	.93	192	.91	1.00	1.04	1.07	1.00	1.07	1.04	-94	•91	•97	•90		
. .	•98	•89	.87	•96	1.00	1.02	1.03	1.03	1.00	91		493		•79	
	• 88	. 67	.85	•94	.98	1.00	1.01	1.00	.98	-88	-85	•91	.84	•77	
	-87	-86	.84	•93	.97	.99	1.00	.99	.97	-88	.84	•90	.83	•77	
**	•88	• 86	.85	•94	.97	1.00	1.01	1.00	.98	<u>. 88</u>	. 85	-91_	.84		
	•90	•89	.87	-96	1.00	1.02	1.03	1.03	1.00	•90	.87	•93	.66	•79	
- <u>8</u> -	99	• 98	- 76-	1.06	1.10	1.13	1.14	1.13	1.11	1.00	-96	1.03	•95	.67	
	1.03	1.02	1.00	1.10	1.15	1.17	1.18	1.18	1.15	1.04	1.00	1.07	.99	-91	
	•96	.95	.93	1.03	1.07	1.10	1.11	1.10	1.07	•97	•93	1.00	≥	.85	
.:-	T:04	I:03.	1.01	1.11	1.16	1.19	1.20	1.19	1.16	1.05	1.01	1-08	1.00	-92	
	1.13	1 - 12	1.10	1.21	1.26	. 20		1.30	1 70					1 00	
	FARLE			1.57	1,40	1.29	1.31	1,50	1.26	1.)4	1.10	1.18	1.09	1.00	
2 E .	FABLE NGTH= - 1	10.	15.	50+	25.	30.	35.	40•	45.	50.	55.	60-	65.	70.	
ELE	NGTH=*•≀	10.	15.	50+	25.	30.	35.	40 ·	45.	50.	55: *****	60•	65.	70.	
ELE.	1GTH=***	10.	15.	20.	25. *00000	30.	35.	40 ·	45.	50.	55: *****	60. ******	65.	70.	
6	0.00	28	15. 6466666	20. *******	25. *0#8894 -1.08	30. ******	35. *******	40 * * * * * * * * * * * * * * * * * * *	45. ************************************	50. ******	55: ******* *1:29	60. *******	65. *******	70. ****** -1.21	
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0.00	28	15. ••••••• •••6 ••19	20. ******** -*37	25. ******** -1.08	30. 	35. ************************************	40: eseeeee -1:47	45. ************************************	50. ************************************	55: ******* *1.29	60. •****** •1.48	65. ************************************	70. 	
000	0-00 -28	10. 28 0.00	15. ************************************	20. 87 56	25. ************************************	30. -1.28 96	35. ************************************	-1.47 -1.14	45. ************************************	50. ******* -1.32 -1.04	55. ****** *1.29 -1.01 82	60. -1.48 -1.18 98	65. -1.34 -1.07	70. ***** -1.21 95 78	
	0.00 -28 -46	28 00 12	15. 46 19 r.00	20. ******* 87 **-56 **-35	25. ******** *-1.08 *76 *54 *17	30. ************************************	35. ******** **1.39 ************************************	-1.47 -1.14 -2.92	45. -1.48 -1.16 94	50. ************************************	55. ******* *1.29 -1.01 82	60. -1.48 -1.18 -,98	65. ******** ~1.34 -1.07 88	70. ****** -1.21 95 78	
	0-00 -28 -48 -81	28 0-00 -12 -52	15. 46 19 r.00 .32	20878735 0-00	25. ************************************	301.2B967436	35. -1.39 -1.06 84 28	-1.47 -1.14 54	45. *1.48 *1.16 94 57	50. ************************************	551.29 -1.018250	60- -1-48 -1-18 ,98 64	651.34 -1.078856	70. ***** -1.21 95 78 49	
	0-00 -28 -46 -81	28 28 28 28 28 29 52 57 83	15. 46 19 00 .32 .47	20. •****** 27 35 0-00 •17 •34	25. *080000 -1.08 76 54 17 0.00	30. -1.28 96 74 36	35. ************************************	-1.47 -1.14 92 54	45* ***********************************	50. ******* -1:32 -1:04 -:86 -:51 -:35	55- ******** *1.29 -1.01 82 50 *.35	60. ************************************	65. -1.34 -1.07 88 56 41	70. -1.21 95 78 49 35 21	
	0-00 -28 -48 -81 -97	28 28 28 28 29 52 57 83 91	15. 	20. 87 56 35 0.00 -17	25. ************************************	30. -1.28 96 74 36 18 0.00	35. ************************************	-1.47 -1.1492543618	45. ************************************	56. ************************************	-1.29 -1.0182503520	60. -1.48 -1.18 98 64 47 31	651.34 -1.0788564126	70	
E E E E E E E E E E E E E E E E E E E	0.00 .28 .46 .81 .97 1.12 1.21	28 28 00 12 52 67 83 91	15. 46 19 10 32 47 62 70	20	25. *080000 -1.08 76 54 17 0.00 .18 .27	30. -1.28 96 74 36 18 0.00	35. ************************************	-1.47 -1.149254361809	45. 45. 46.46 1.48 1.16945740 4.2213	50. ******* -1:32 -1:04 -:86 -:51 -:35 -:19 -:10	-1.29 -1.018250352012	60. -1.48 -1.18 98 64 47 31 22	65. ********* *1.34 -1.078856 **.412618	70. 	
	0.00 -28 -48 -81 -97 1.12 1.21 1.23 1.32	28	15. 46 19 1	20. 87 87 35 0.00 -17 -34 -42 -51 -55	25. ************************************	30. -1.28 96 74 36 18 0.00 .09 .19	35	-1.47 -1.1492541809	45. ************************************	50. ******* -1-32 -1-0484513519100301 0-00	55- ***********************************	60. -1.48 -1.18 98 64 47 31 22 14 10	651.34 -1.0788564126181107	70. •**** -1.2195784935211407	
	0.00 .28 .48 .81 .97 1.12 1.21 1.22 1.32 1.33	10	15. 46 19 00 .32 .47 .62 .76 .82 .81	20	25. ************************************	30	35. -040*s* -1.39 -1.06 84 06 28 00 0.00 .09 .13 .12	-1.47 -1.1492541809 0.00 .05	-1.48 -1.1694574022130000	50. ******* -1:32 -1:04 -:84 -:81 -:35 -:19 -:03 -:01 0:00	55. ****** *1.29 -1.018250352012 *.040002	-1.48 -1.1898644731221012	-1.07885618110708	70. •**** -1.21957849352114075405	
	0-00 -28 -48 -81 -97 1-12 1-21 1-28 1-31 1-33 1-42	2800125257839199 1.03 1.01 1.03 1.13	15. 46 19 00 .32 .47 .62 .70 .76 .81 .82	20. 87 87 35 0-00 -17 -34 -42 -51 -55 -66	25. ************************************	301.2896743618 0.00 0919232123	35. ************************************	-1.47 -1.149254361809 0.00 .05 .03	-1.48 -1.16945740221309 0.0001	50. ******* -1:22 -1:04 -:84 -:51 -:35 -:19 -:10 -:03 -:01 0:00 -:02	55- ******* -1-29 -1-018250352012040002 0.00	-1.48 -1.189864473122141012	-1.0788561811078800	70	
	0.00 .28 .48 .81 .97 1.12 1.21 1.22 1.32 1.33	10	15. 46 19 00 .32 .47 .62 .76 .82 .81	20	25. ************************************	30	35. -040*s* -1.39 -1.06 84 06 28 00 0.00 .09 .13 .12	-1.47 -1.1492541809 0.00 .05	-1.48 -1.1694574022130000	50. ******* -1:32 -1:04 -:84 -:81 -:35 -:19 -:03 -:01 0:00	55. ****** *1.29 -1.018250352012 *.040002	-1.48 -1.1898644731221012	-1.07885618110708	70. •**** -1.21957849352114075405	

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Modeï

0.01	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	
•															
. 0.	0.00	16	28	46	++ 6i)	71	7A	83	83	-+A4	85	92	89	80	
	15	0+90	12	~.29	41	52	+.58	~. 03	64	<u>,65</u>		73	70	63	
	•26	-11	0.00	16	25	38	44	49	51	52	51	59	57	51	
	-44	•26	.15	0 - 0 0	11	21	26	32	-,33	35	34	42	40	35	
	.49	-35	.24	-10	0.00	10	15	20	22	24	24	31	29	-,26	
, 0	•57	.43	.32	-19	.09	0 • 0 0	05	10	13	15	15	21	~.20	17	
à ··	-16-	.47	.37	• 24	•15	• 05	0.00	05	07	10	10	16	15	12	
	• 65	152	.41	-28	.19	•10	.05	0.00	-02	05	05	11	10	08	
	•67	.54	•43	-31	•55	•13	•0R	.02	0.00	02	03	08	0A	06	•
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| 20.0 | .85 | .91 | .95 | 1.00 | 1.03 | 1.02 | •99 | 1.03 | 1.04 | .97 | .94 | •90 | .87 | .81 | |
| 52.0 | .83 | •68 | .92 | • 47 | 1.00 | .99 | •96 | 1.00 | 1.01 | -94 | •91 | . 87 | .84 | •79 | |
| 30.4 | .84 | - 69 | .93 | • 48 | 1.01 | 1.00 | -97 | 1.01 | 1.02 | .95 | .92 | •88 | •85 | .79 | |
| 35.0 | .86 | •92 | .96 | 1.01 | 1.04 | 1.03 | 1.00 | 1.03 | 1.05 | •98 | .95 | •90 | .87 | .81 | |
| 40.0 | -83 | .88 | .93 | • 47 | 1.00 | .99 | •97 | 1.00 | 1.01 | .95 | .92 | .87 | .84 | •79 | |
| 45.6- | | .87 | .92 | • 76 | .99 | •98 | .95 | . 99 | 1.00 | .94 | .91 | •86 | .84 | •78 | |
| 50.0 | 88 | •94 | .98 | 1 • 63 | 1.06 | 1 • 05 | 1-02 | 1-06 | 1.07 | 1.00 | •97 | •92 | -89 | -83 | |
| 55.0 | •90 | • 97 | 1.01 | 1.06 | 1.09 | 80 • f | 1.05 | 1.09 | 1.10 | 1.03 | 1.00 | •95 | •92 | •86 | |
| 60.0 | .95 | 1.01 | 1.06 | 1:11 | 1.15 | 1.14 | 1.11 | 1.15 | 1.15 | 1.08 | 1.05 | 1.00 | .97 | •90 | |
| 65.0 | • 98 | 1.05 | 1.10 | 1.15 | 1.19 | 1.17 | 1.14 | 1.18 | _1,21_ | 1.12 | 1.08 | 1.03 | 1.00 | .93 | |
| 70.8 | 1.05 | 1.12 | 1.18 | 1 - 24 | 1.27 | 1.26 | 1.23 | 1.27 | 1.23 | 1.20 | 1.16 | 1-11 | 1.07 | 1.00 | |
| | TABLE | 75 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | 5. | 10. | 15. | 50- | 25. | 30. | 35. | 90 e | 45. | 50. | 55. | 60. | 65. | 70. | |
| 04 | 5. | 10. | ***** | 044 0 44 | **** | p 0 0 0 0 0 0 0 0 | ***** | n a a a a a a | ***** | **** | **** | **** | **** | ***** | |
| 5,0 | 0.00 | 19 | ************************************** | ÷.49 | -,59 | 05 | 67 | 76 | -,8: | 76 | 75 | 72 | 70 | 64 | |
| 10.0 | 0.00
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0-00 | ~J4
~}4 | -,49
-,28 | 59
37 | -•05
-•44 | 67
46 | -•76
-•54 | -,8:
-,5° | 76
56 | 75
55 | -•72
-•53 | 70
51 | 64
46 | |
| 10.0 | 0.00
•18 | 19
0-00
13 | 14
14 | -,49
-,28
-,13 | 59
37
22 | | | 76
54
39 | -,8:
-,5: | 76
56
41 | 75
55
41 | 72
53 | 70
51
38 | 64
46
34 | |
| 10.0 | 0.00
•18 | 19
0-00 | ~J4
~}4 | -,49
-,28 | 59
37 | | 67
46 | -•76
-•54 | -,8:
-,5° | 76
56 | 75
55 | -•72
-•53 | 70
51
38 | 64
46 | |
| 10.0 | 0.00
•18 | 19
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13 | 14
14 | -,49
-,28
-,13 | 59
37
22 | | | 76
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39 | -,8:
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41 | 75
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41 | 72
53 | 70
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38 | 64
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34 | |
| 19.0 | 00.00
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01.4 | 19
0.00
-13 | 34
14
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13 | 59
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22 | | 67
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39 | -,8:
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41 | 75
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41 | 72
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40 | 70
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38 | 64
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| 19.0 | 0.00
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61.
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731 | 19
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-25 | 14
14
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22
08 | | 67
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18 | 76
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26 | -,8:
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-,4:
-,3: | 76
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29 | 75
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29 | 72
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28 | 70
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27 | 64
46
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24 | |
| 15.0 | .18
.31
.42 | 19
0.00
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-33 | JA
14
0.00
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.20 | 49
28
13
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08 | 59
37
22
08
0.00 | | | 76
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39
26
17 | -,8:
-,5:
-,4:
-,3:
-,2: | 76
56
41
29
21 | 75
55
41
29
21 | 72
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28
20 | 70
51
38
27
20 | 64
46
34
24
17 | |
| 19.0
19.0
20.0
25.0
30.0 | | 10.
19
0.00
-13
-25
-33
-39 | JA
14
0.00
-13
-20
-27 | 49
28
13
0.00
08
15 | 59372208 0.00 .07 | 06
44
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16
07
0.00 | 674631181003 | 76
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17
10 | -,8:
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41
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14 | 72
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14 | 70
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38
27
20
14 | 64
46
34
24
17
11 | |
| 19.0
19.0
20.0
25.0
30.0 | | 19
0.00
13
25
33
39
42 | JA14 0.00 -13273936 | 492813 0.0008151825 | 59372208 0.00 .07 .17 | | | 76
54
39
26
17
10 | -,8:
-,5:
-,4:
-,3:
-,2:
-,1:
-,1:
-,0: | 76
56
41
29
21
14 | 75554129211411 | 72534028291411 | 70
51
38
27
20
14
11 | 64463424171109 | |
| 19.0
15.0
20.8
25.0
30.0
35.0 | | 19
0.00
-13
-25
-33
-39
-42
-48
-52 | JA14 0.00 .13 .20 .27 .30 .36 | 492813 0.0098151825 | 59372208 0.0007101721 | 6644291607 0.00 -03 -10 | | 76543926171007 0.00 | -,8:
-,5:
-,4:
-,3:
-,2:
-,1:
-,0:
0,0: | 76
56
41
29
21
14
11
04 | 75554129211405 | 7253402820141105 | 7051382720141105 | 6446342417110904 | |
| 20.8
20.8
20.8
30.0
45.0 | .63
.65 | 19
0.00
-13
-25
-33
-39
-42
-48
-52 | JA14 0.00 -132027364041 | 49
28
13
0.00
.08
.15
.18
.25
.29 | 59372208 0.00 .07 .10 .17 .21 | | 674631181903 0-00 -07 | 76
54
39
26
17
10
07
0.00 | -,8: -,5: -,4: -,3: -,2: -,1: -,0: 0,0: | 765641292114110401 | 755541292114110501 | 72
53
40
28
29
14
11
05
02 | 705138272014110502 | 644634241711090400 | |
| 20.5
25.4
30.4
35.4
45.6 | .66 | | JA14 0.D0 -132739364041 | 492813 0.00081518252930 | 59372208 0.00 .07 .10 .17 .21 .22 .23 | | 674631181003 0.00 .07 .11 .11 | 76543926171007 0.00 .04 .05 | -, 6:
-, 5:
-, 4:
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-, 2:
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-, 0:
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, 0: | 7656412921140401 0.00 | 75554129211411050101 | 72534028291411050201 | 70513827201411050201 | 644634241711090400 .00 | |
| 19.0
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.53 | JA14 0.00 -1320273936404141 | 492813 0.00081518252930 | 59372208 0.00 .07 .10 .17 .21 .22 .23 | 6644291667 0.00 .03 .10 .14 .15 .15 | | 76543926171007 0.00 .04 .05 | -,8: -,5: -,4: -,3: -,2: -,1: -,0: 0.0c .01 .02: .02 | 765641292114110401 0.000102 | 75554129211411050101 0-00 -01 | 7253402820141105020101 | 7051382720141105020100 | 644634241711090400 .00 .01 | |

han esta Thiodha Thibriotha to ddo cardi. Bagarte in cinnessa e cardinarada. Di americana a cardinarada comuni

ALPHA TABLE

WAVELENGTHE .75
5. 10. 15. 20.

| prii |
|------|
| 1 |
| Mod |
| ē |

| A ST FL | TABLE
VOTH= -4 | _ | | 74 | 95 | | | | | | | | | | - |
|-----------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------|-----------------------------|--------------------------------|------------------------|------------------------------|----------------------------|----------------------------|-----------------------|------------------------------|---|
| | 2. | | 15. | 20. | 25.
******* | 30. | 35. | 40+ | 45.
******* | 50 | 55.
****** | 60.
******** | 65.
******* | 70. | |
| 5. * | 1.00 | 1.06 | 1.10 | 1.16 | 1.20 | 1-19 | 1+16 | 1-20 | 1.21 | 1.13 | 1-10 | 1.05 | 1.01 | .95 | |
| D. • " | •95 | 1.00 | 1.04 | 1.09 | 1.13 | 1.12 | 1-10 | 1.13 | 1.14 | 1+07 | 1.04 | •99 | .96 | .90 | |
| 5.a | 90 | <u>•96</u> | 1.00 | 1.05 | 1.08 | 1.6/ | 1.05 | 1.09 | 1.09 | 1.03 | •99 | <u>•95</u> | .92 | -86 | |
| 4.0 | •86 | -91 | •95 | 1.00 | 1.03 | 1.03 | 1.00 | 1.04 | 1.04 | •98 | -95 | •91 | .88 | .82 | |
| 5.8"
6 | 84 | 88 | .92 | •97 | 1.00 | .99 | .97 | 1.00 | 1.01 | -95 | •92 | -88 | .85 | .79 | |
| 0.0 | | .89 | .93 | •97 | 1.01 | 1+00 | •9a | 1.01 | 1.02 | •95 | .92 | -88 | <u>. 85</u> | -80_ | |
| 5.* | -86 | •91 | .95 | 1-00 | 1.03 | 1.02 | 1.00 | 1.03 | 1.04 | •98 | •94 | •90 | .87 | .82 | |
| 0.87 | | .88 | .92 | •96 | 1.00 | .99 | 97 | 1.00 | 1.01 | +94 | .91 | .87 | .85 | .79 | |
| 5. a
- a | <u>- 83</u> | | 91 | •96 | .99 | •98 | •94_ | .99 | 1.00 | <u> •94</u> | •91 | <u>•87</u> | 48. | .78 | |
| 0.+ | •88 | .93 | .98 | 1.05 | 1.05 | 1.05 | 1.02 | 1.06 | 1.07 | 1.00 | •97 | •92 | •90 | .84 | |
| 5.4 | -91 | • 96 | 1.01 | 1-05 | 1.09 | 1.08 | 1.06 | 1.09 | 1.10 | 1.03 | 1.00 | •95 | .92 | .86 | |
| 0.0 | •95 | 1.01 | 1.06 | 1-10 | 1.14 | 1.13 | 1.11 | 1.15 | <u>l.15</u> _ | 1.08 | 1.05 | 1.00 | - 97 | <u>.91</u> | |
| 5.* | • 99 | 1.04 | 1.09 | 1-14 | 1.18 | 1.17 | 1.15 | 1.18 | 1.19 | 1.12 | 1.08 | 1.03 | 1.00 | •93 | |
| 0.0 | 1.05 | 1-12 | 1.17 | 1.22 | 1.26 | 1.25 | 1.23 | 1.27 | 1.27 | 1.20 | 1.16 | 1+10 | 1.07 | 1.00 | |
| ETA" | TABLE | | | | | | | | | | | | | | |
| _ | 461H= .9
5. | 10. | 15 | 20. | 25. | 30 | 35. | 40- | 45 | 50. | 55. | _60• | 65. | 70. | |
| ۰ | o d च च च च च च | | | | | | ***** | **** | ******* | ***** | **** | ***** | **** | ***** | |
| 5.0 | 0.00 | 05 | -,10 | 14 | 18 | 20 | 21 | 24 | <u>.26</u> _ | 24 | 24 | 23 | 21 | 19 | |
| 0.•
 | •05 | 0.00 | 04 | 08 | 12 | 14 | 15 | 18 | 20 | 18 | 18 | 17 | 16 | 15 | |
| 9.3 | 09 | • 04 | 0.00 | 04 | 07 | 10 | 11 | -,14 | 15 | 14 | 14 | 13 | 13 | 11 | |
| · | .12 | • 08 | .04 | 0.00 | 03 | 06 | 07 | 09 | <u>11</u> | 10 | 10 | -+1 <u>0</u> | 09 | 08 | |
| | | | | | | | _ | | | | | | | | |
| 5.0 | •15 | -10 | .07 | •03 | 0.00 | 03 | 04 | 06 | 08 | 07 | ~• 07 | 07 | 06 | 05 | |
| o. <u>-</u> - | •15 | •10
•13 | .07 | •03 | 0.00 | 0.00 | 04 | -,04 | 08 | 07
05 | ₩•07
₩•05 | -+07 | 06 | 05 | |
| • | _ | | | | | | | | | | | | | | |
| 5.0 | •17 | •13 | .09 | •05 | .03 | 0.00 | 01 | -,04 | ₩, 05 ° | 05 | ~.05 | 05 | 04 | 03 | |
| 0.0 | •17 | •13
•14 | .09 | •07 | .03 | 0.00 | U1
0.0g | 04 | ~. 05 | ∩5
04 | 04 | 05 | 04 | 02 | |
| 5.0 | •17
•18
•20 | •13
•14
•16 | .09
.10 | •07 | .04 | •04
•04 | ••••
•••• | 04
02 | C4
01 | 05
04
01 | 04
01 | 05
04
01 | 04
03
01 | 02
00 | |
| 0.0 | •17
•18
•20
•21 | •13
•14
•16
•17 | .09
.10
.13 | •05
•07
•n9
•10 | .04
.06 | •04
•04
•04 | U1
0.00
.02
.04 | 04
02
0.00 | 05
04
01
0.00 | 05
04
01
00 | 05
04
01
00 | 05
04
01
00 | 04
03
01 | 02
00
00 | |
| 0.0 | •17
•18
•20
•21
•21 | •13
•14
•16
•17
•17 | .09
.10
.13
.14 | •07
•09
•10
•10 | .04
.04
.06
.08 | 0.00
.01
.04
.05 | 0.00
0.00
0.02
.04 | 04
02
0.00
.01 | 01
0.00 | 05
04
01
00
0-00 | 04
01
00 | 05
04
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00 | 04
03
01
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01 | |
| 0.0 | •17
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.08 | 0.00
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.05 | 0.00
0.00
.02
.04 | 04
02
0.00
.01
.01 | C4
C1
0.00
C0 | 05
04
01
00
0-00 | 05
04
01
00
00 | 05
04
01
00
00 | 04
03
01
.00 | 02
00
00
.01
.01 | |

SUN ANGLE CORRECTION COEFFICIENT TABLES FOR MAY (MODEL DERIVED CANOPY REFLECTANCE)

TABLE XI.

| MAVELE | TABLE
TOTHE : | 10 | 15. | 20. | 25. | 30. | 35. | 40• | 45. | 50. | 55. | 60. | 65. | 70. |
|---|---|---|---|---|---|--|---|--|--|---|--|---|---|--|
| b | | ***** | 0 0 0 0 0 0 0 0 | 0.40000 | ***** | ****** | **** | **** | **** | | **** | **** | **** | *** |
| 5.0 | 1.00 | 1.03 | 1.05 | 1.15 | 1.18 | 1 • 2 4 | 1.31 | 1.28 | 1.24 | 1.25 | 1.20 | 1.16 | 1.10 | 1.03 |
| ~]D,• | .97 | 1.00 | 1.02 | 1-11 | 1.15 | 1.20 | 1.27 | 1.25 | 1.20 | 1.22 | 1.17 | 1-13 | 1.07 | 1.00 |
| 15. | •95 | •98 | 1.00 | 1.09 | 1.12 | 1 - 18 | 1.24 | 1.22 | 1.18_ | 1.19 | 1.14 | 1,10 | 1.05 | 98 |
| 20.0 | .87 | •90 | .92 | 1.00 | 1.03 | 1.08 | 1.14 | 1.12 | 1.08 | 1.10 | 1.05 | 1.01 | •96 | .90 |
| 25. | •85 | | .89 | .97 | 1.00 | -T.05 | 1.11 | 1.09 | 1.05 | 1.06 | 1.02 | •98 | .93 | -87 |
| 30.0 | -81 | .83 | .85 | .92 | .95 | 1.00 | 1.06 | 1.04 | 1.00 | 1.01 | •97 | 94_ | .89 | .83 |
| 35. | .76 | .79 | .80 | •87 | .90 | .95 | 1.00 | .98 | .95 | .96 | •92 | •89 | .84 | •79 |
| 40.0 | | 80 | .02 | . B9 | -92 | 96 | 1.02 | 1.00 | .96 | - 98 | 94 | •90 | .86 | -80 |
| | | | | •92 | .95 | 1.00 | 1.06 | 1.04 | 1.00 | 1-01 | .97 | .94 | .89 | .83 |
| - 45.0 | •81 | - · B3 | .85 | | .94 | .99 | 1.04 | 1.02 | .99 | 1.00 | •96 | .93 | .88 | .82 |
| 50. | •80 | -82 | .84 | •91 | | | | | | | 1.00 | •96 | •91 | .85 |
| 55.e
 | -83 | -86 | .87 | •95 | .98 | 1.03 | 1.09 | 1.07 | • | 1.04 | | | = | .89 |
| 60. | -86 | -89 | .91 | - 99_ | 1.02 | 1.07 | 1.13 | | | 1.08 | 1.04 | 1+08 | .95 | |
| 65.0 | •91 | . 94 | .96 | 1.04 | 1.07 | 1.12 | 1.19 | 1.17 | 1.13 | 1.14 | 1.09 | 1.05 | 1.00 | .93 |
| 70.8 | •97 | T-00- | 1.02 | 1.11 | 1.15 | 1.20 | 1.27 | 1.25 | 1.20 | 1.22 | 1.17 | 1.13 | 1.07 | 1.00 |
| | | | | | | | | | | | | | | |
| "RETA | TABLE | | | | | | | | | | | | | |
| WAVELO | TABLE . | CC | 15. | |
25. | 304 | 35. | 40. | 45. | 50. | 55. | 60. | 65. | 70. |
| WAVELO | Bits Teen - | CC | 15. | 20. | 25.
V40000 | 30. | 35. | 40. | 45. | 50, | 55. | 60. | 65. | 70.
****** |
| WAVELO | NuT≃= =
5.
 | 55
10. | 15.
15.
15.68 | | | | | | | | | | | |
| WAVEL! | NuT≃= =
5.
 | 55
10. | -1.68 | | -2.93 | -3.49 | -3.98 | -4.06 | -3.98 | -4-19 | -4-05 | | -3,74 | -3,48 |
| WAVEL! | 0.00 | 10.
10.
-1.02
0.00 | -1.68 | -2.53_ | -2.93
-1.77 | -3.49
-2.27 | -3.98
-2.69 | -4.06
-2.79 | -3.98
-2.76 | -4.19
-2.95 | -4.05
-2.86 | +3•95 | -3,74
-2,65 | -3.48
-2.46 |
| 5.4
5.4 | NuT≃= •
5.
•••••• | 10.
10.
-1.02
0.00 | -1.68
65 | -2.53
-1.40 | -2.93
-1.77 | -3.49
-2.27
-1.51 | -3.98
-2.69
-1.88 | -4.06
-2.79
-2.00 | -3.98
-2.76
-2.00 | -4.19
-2.95
-2.18 | -4.05
-2.86
-2.13 | +3.95
+2.81 | -3,74
-2.65
-1.98 | -3.48
-2.46
-1.83 |
| 5.4
10.0
10.0 | 0.00
.99 | -1.02
0.00 | -1.68
65 | -2:53
-1:40
-:70 | -2.93
-1.77
-1.04 | -3.49
-2.27
-1.51 | -3.98
-2.69
-1.88 | -4.06
-2.79
-2.00 | -3.98
-2.76
-2.00
-1.25 | -4.19
-2.95
-2.18 | -4.05
-2.86
-2.13
-1.39 | -3.95
-2.81
-2.10
-1.39 | -3.74
-2.65
-1.98
-1.31 | -3.48
-2.46
-1.83 |
| 5.a
10.0
19.8
20.0 | 0.00
.99
1.60
2.21 | 10.
10.
10.
10.
10.
10.
10.
10.
10.
10. | -1.68
65
0.00
.64 | -2.53
-1.40
70
0.00 | -2.93
-1.77
-1.04
32 | -3.49
-2.27
-1.51
76 | -3.98
-2.69
-1.88
-1.09 | -4.06
-2.79
-2.00
-1.22 | -3.98
-2.76
-2.00
-1.25 | -4.19
-2.95
-2.18
-1.42
-1.07 | -4.05
-2.86
-2.13
-1.39 | -3.95
-2.81
-2.10
-1.39 | -3.74
-2.65
-1.98
-1.31 | -3.48
-2.46
-1.83
-1.21 |
| 10.00
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20.00
25.00 | 0.00
.99
1.60
2.21
2.48 | -1.02
0.00
.63
1.26
1.54 | -1.68
65
0.00
.64
.93 | -2.53
-1.40
70
0.00 | -2.93
-1.77
-1.04
32 | -3.49
-2.27
-1.51
76 | -3.98
-2.69
-1.88
-1.09 | -4.06
-2.79
-2.00
-1.22 | -3.98
-2.76
-2.00
-1.25
90 | -4.19
-2.95
-2.18
-1.42
-1.07 | -4.05
-2.86
-2.13
-1.39 | -3.95
-2.81
-2.10
-1.39
-1.07 | -3.74
-2.65
-1.98
-1.31
-1.01 | -3.48
-2.46
-1.83
-1.21
92 |
| 5.4
10.0
13.8
20.0
25.0 | 0.00
.99
1.60
2.21
2.48
2.82
3.04 | 55
10.
-1.02
0.00
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** | 5. | 10. | 15. | 20. | 25. | 30. | 35. | 40. | 45. | 50. | 55. | 60. | 65. | 70. | |
|------------------|---|--|---------------------------------------|------------------------------------|--|---|---|---|--|---|--|---|--|---|-------------|
| ٠ | | ************************************** | | ******** | 400000 | | ***** | | |)
} | **** | ***** | ***** | ***** | <u> </u> |
| 6 | 1.00 | 1.05 | 1.09 | 1.18 | 1.19 | 1.30 | 1.33 | 1.33 | 1.27 | 1.31 | 1.27 | 1.22 | 1,17 | 1.09 | |
| | 95 | 1.00 | 1.04 | 1.12 | 1.13 | 1.24 | 1.26 | 1.27 | 1.21 | 1.25 | 1.21 | 1-16 | 1.11_ | 1.04 | |
| | •92 | • 96 | 1.00 | 1.08 | 1.09 | 1.19 | 1.22 | 1.22 | 1.17 | 1.20 | 1.16 | 1.12 | 1.07 | 1.00 | |
| | -85 | . 89 | .93 | 1.00 | 1.01 | 1-10 | 1.13 | 1.13 | 1.03 | 1.11 | 1.08 | 1.03 | .99 | .93 | |
| • • | -84 | •88 | .92 | •99 | 1.00 | 1.09 | 1.11 | 1.12 | 1.07 | 1.10 | 1.06 | 1.02 | .98 | .92 | |
| | .77 | •B1 | . 84 | •91 | •92 | 1.00 | 1.02 | 1.03 | .93 | 1.01 | .97 | .94 | •90 | .84 | |
| , 5 - | 75 | .79 | .82 | -89 | •90 | -98 | 1.00 | 1.00 | ē 5 | | .95 | •92 | .88 | .02 | · · · · · · |
| • | - 75 | •79 | .82 | •88 | .89 | •97 | 1-00 | 1.00 | .95 | -98 | •95 | •91 | .88 | .82 | |
| * | .79 | •83 | .86 | •93 | .94 | 1.02 | 1.05 | 1.05 | 1.0) | 1.03 | 1.00 | •96 | .92 | .B6 | |
|) * e | 76 | Во | .83 | •90 | 91 | .99 | 1.01 | 1.02 | <u> </u> | 1.00 | •97 | •93 | . 89 | .83 | |
| . 5 | -79 | •B3 | .86 | •93 | .94 | 1.03 | 1.05 | 1.05 | 1.01 | 1.03 | 1.00 | •96 | •92 | .86 | |
| ь
1 т | .82 | •86 | .90 | •97 | .98 | 1.07 | 1.09 | 1.10 | 1.0. | 1.08 | 1.04 | 1.00 | 496 | •90 | • |
| | | • 90 | .93 | 1:01 | 1.02 | 1.11 | 1.14 | 1.14 | 1.0 | 1-12 | 1.08 | 1.04 | 1.00 | •93 | |
| | •92 | •96 | 1.00 | 1.0B | 1.09 | 1.19 | | 1.22 | | | | | - | | |
| | T+D: = | | | | | | | | <u>^</u> **- | 1020 | 1.16 | 1.11 | 1.07 | 1=00 | |
| LE | TABLE
NGTH= | 10. | 15. | 20. | 25. | 30. | 35. | 40. | 45. | 50. | 55. | 60. | 65. | 70. | |
| ELE | NGTH= . | 10. | ***** | ****** | 25.
****** | 30. | 35. | 40.
2000#20 | 45. | 50. | 55.
******* | 60.
****** | 65. | 70. | |
| ELE | NGTH= .0 | 10. | 72 | -1-09 | 25.
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************************************ | 50.
******* | 55.
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*1.76 | 40.
************************************ | 45.
************************************ | 50. | 55.
******* | 60.

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| ELE | 0.00
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77
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| | 0.00
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| | 0.00
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| 14EFE | TABLE . | | | | | | | | | | | | | | |
|--|--|---|--|---|--|---|--|---|--|--|--|--|--|---|-------------|
| pe | 5.
Topper | 10.
##0#### | # <u>@###</u> | ************************************** | 25.
******* | 30. | 35. | 40.
***** | 45. | 50. | 55. | 60. | 65. | 70. | |
| 5, ¢ | 1.00 | 1.05 | 1.09 | | | | | | | | | | | | |
| | ***** | 1,03 | 1,07 | 1.12 | 7.14 | 1921 | 1 • 23 | 1.35 | 1,55 | 1.29 | 1 4 2 4 | 1,51 | 1.15_ | 1 + 0 4 | |
| 10.0 | • 95 | 1.00 | 1.04 | 1.09 | 1.13 | 1.21 | 1.26 | 1.25 | 1.22 | 1.23 | 1.18 | 1.15 | 1.10 | 1.04 | |
| 15.* | .91 | •96 | 1.00 | 1.05 | 1.08 | 1.16 | 1.21 | 1.21 | 1.17 | 1.18 | 1.14 | 1.10 | 1.06 | 1.00 | |
| 20. | 67 | .92 | . 95 | 1.00 | 1.03 | 1-11 | 1,16 | 1.15 | 1,15 | 1.13_ | 1.09 | 1.05 | 1.01 | 95 | |
| 25.0 | -84 | •89 | .92 | ٠97 | 1.00 | 1.07 | 1.12 | 1.11 | 1.08 | 1-09 | 1.05 | 1.02 | •9B | .92 | |
| 30.* | .79 | - 83 | .86 | -90- | ee | | 1.04 | 1.04 | 1.01 | 1.02 | .98 | •95 | .91 | .86 | |
| 35.* | •75 | •79 | .82 | •86 | .89 | •96 | 1.00 | .99 | .97 | 97_ | •94 | 91 | .87 | -82 | |
| .0. | •76 | •80 | .83 | -87 | .90 | •96 | 1.01 | 1.00 | .97 | •9B | ,94 | .92 | .88 | .83 | |
| #
5.4 | | 82 | .85 | .89 | .92 | | 1.03 | | | | .97 | 94 | .90 | .85 | |
| 50.# | .77 | .81 | .85 | •89 | .92 | | 1.03 | | | _ | .96 | .93 | - •90_ | | |
| 55.* | 80 | •85 | .88 | •92 | 95 | | 1.07 | 1.06 | 1.03 | 1.04 | 1.00 | •? <u>•</u> | | | *** |
| | | - | | | | | | | | | | | .93 | •88 | · ···· |
| 50.4 | .83 | -87 | .91 | 95 | 98 | 1.05 | 1.10 | 1.09 | 1.06 | 1.07 | 1.03 | 1.00 | •96 | .90 | |
| 55 | 86_ | •91 | .95 | •99 | 1.02 | 1.10 | 1.15 | 1.14 | 1.11 | 1.12 | 1.08 | 1.04 | 1.00 | .94 | |
| 70.0 | .92 | •97 | 1.00 | 1 + 05 | 1 40 | 1.17 | 1 24 | | | 1 .0 | | | | | |
| | | | 1.00 | 1.05 | 1.09 | 1.17 | 1.22 | 1,51 | 1.18 | 1.14 | 1.14 | 1.11 | 1.06 | 1.00 | |
|
3£74 | TABLE
NGTH# .1 | 75 | | | | | | | | | | · | | | |
|
3£74 | | | 15. | 20. | 25. | 30. | 35. | 40. | 45. | 20. | 55. | 60. | 65. | 70. | |
|
3£74 | NGTH= . | 75
10. | | 20. | 25. | 30. | 35. | 40. | | 50. | 55. | 60. | 65. | 70. | |
| BÉTA
AVELE | NGTH= .1 | 75
10. | 15. | 20. | 25. | 30. | 35. | 40. | 45.
******** | 50. | 55. | 60.
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| SETA
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 | 70.
78 | |
| 36TA
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13 | 20.
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••61 | 40.
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66 | 45.
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************************************ | 55.
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68 | 60.
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13
0.00 | 20.
************************************ | 57
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55 | 89
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************************************ | |
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| 36.TA
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01 | 70 | |

| 15.* | 92_ | +97 | 1.00 | 1.05 | 1.09 | 1.16 | 1.21 | 1.20 | _1:17_ | 1.17 | 1.13 | 1.09 | 1,04 | •98 |
|---|---|--|--------------------------------|--|---------------------------|---------------------------------|-----------------------------------|-----------------------------|--|----------------------------|----------------------------------|----------------------------|--|----------------------------|
| 50. | -88 | •92 | .95 | 1+00 | 1.03 | 1.10 | 1.15 | 1.14 | 1.11 | 1.11 | 1.07 | 1+04 | .99 | .93 |
| 25.6 | +85 | -89 | .92 | -97 | 1,00 | 1.07 | 1.11 | 1.10 | 1.67 | 1.08 | 1.04 | 1.01 | ,96 | .91 |
| 30.0 | -80 | •84 | .86 | -91 | .94 | 1.00 | 1.04 | 1.03 | 1.01 | 1.01 | .97 | .94 | -90 | .85 |
| 35.4 | •76 | .80 | .83 | •87 | 90 | •96 | 1.00 | .99 | .97 | •97 | •93 | •90 | -86 | •81 |
| AU. #- | -77 | .81 | .84 | -88 | | 97 | - • | 1.00 | | | | • | | |
| 45.4 | | _ | _ | _ | | | _ | | | •98 | • 94 | •91 | .87 | .82 |
| | <u></u> | 83 | . 86 | •90 | .93 | 99 | 1.04 | 1.03 | _1.co_ | 1.00 | •97 | •94 | 99 | .84 |
| 50. + | +79 | €3• | .85 | •90 | .93 | .99 | 1.03 | 1.02 | 1.00 | 1.00 | •96 | •93 | .89 | +84 |
| 55.** | 82 | •86 | .89 | -93 | .96 | 1.03 | 1.07 | 1.06 | 1.04 | 1.04 | 1.00 | •97 | •93 | -87 |
| 60. | - 85 | •89 | .92 | -96 | ,99 | 1.06 | 1.11 | 1.10 | 1.07 | 1.07 | 1.03 | 1.00 | •96 | .90 |
| 65,* | -88 | •93 | .96 | 1.01 | 1.04 | 1+11 | 1+16 | 1.15 | 1.12 | 1.12 | 1.08 | 1.05 | 1.00 | •94 |
| 70.5 | -94 | - 98 | 1.02 | 1-07 | 1.10 | 1.18 | 1.23 | 1.22 | 1.19 | 1.19 | 1+14 | 1.11 | 1.06 | 1.00 |
| WAVELE | NGTH# #9 | • | | | | | | | | | | | | |
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.22 | 05 0-00 004 007 -10 -14 -16 -17 -18 -19 | 090407111314151616 | 140604 0-00 -03 -07 -09 -11 -12 -12 | 17116703 0.000406080910 | 2317120804 0.00 .02 .04 .05 .06 | 262015160703 0.00 .02 .02 .04 | 28211712090402 0.00 .01 | 2321170707070707 | 292319141106040201 9.00 | 28221813100604020100 | 27221813100604020100 | 262016120905030201 .00 | 231815110804020100 .01 |

ALPHA TABLE

WAVELENGTH# :95
5. 10. 15. 20. 25. 30. 35. 40. 45. 50. 55. 60. 65. 70.

5.* 1.00 1.05 1.08 1.14 1.18 1.26 1.31 1.30 1.27 1.27 1.22 1.18 1.13 1.07 10.* -95 1.00 1.03 1.09 1.12 1.20 1.25 1.24 1.20 1.21 1.15 1.13 1.08 1.02

| | TABLE
NGTHE •: | 55
10. | 15. | 20. | 25. | 30. | 35. | 40. | 45. | 50. | 55. | 60. | 65. | 70. | | | TABLE XI |
|--|--|---|--|---|---|--------------------------------|----------------------------------|------------------------------------|--|--|--|--|--|--|--------------|-------------|----------------|
| | 5004980 | ***** | ** > 6 0 0 0 | **** | **** | **** | **** | ***** | ***** | **** | **** | **** | **** | **** | | <u></u> | Ξ |
| 5.0 | 1.00 | 1.11 | 1.19 | 1.24 | 1.25 | 1.37 | 1.44 | 1.46 | 1.47 | 1.48 | 1.44 | 1.38 | 1.35 | 1.25 | | | |
| 0.0 | •90 | 1.00 | 1.07 | 1.11 | 1.12 | 1.23 | 1.30 | 1,31 | 1,32 | 1.33 | 1.29 | 1.24 | 1.21 | 1-13 | | | 35 |
| 5. | . • 84 | •93 | 1.00 | 1.04 | 1.05 | _1-15_ | 1,21 | _1,22_ | 1.23_ | 1.25 | 1,21_ | _1.16_ | _1,13_ | 1+05 | | | <u> </u> |
| 20. | -81 | •90 | •96 | 1.00 | 1.01 | 1.11 | 1.17 | 1.18 | 1.19 | 1.20 | 1.16 | 1.12 | 1.09 | 1.01 | | - | SUN ANGLE |
| 5. | BO | . 89 | .96 | •99 | 1.00 | 1.10 | 1.16 | 1.17 | 1.18 | 1.19 | 1.15 | 1:11 | 1,08 | 1.00 | | <u> </u> | <u>j</u> m |
| 30. | • 73 | .81 | .87 | .90_ | .91 | 1.00 | 1.05_ | _1.06_ | 1.07 | _1.08_ | 1.05 | _1.01_ | 98 | 91 | | [| E CORRECTION |
| 5.0 | -69 | •77 | .82 | •86 | .86 | •95 | 1.00 | 1.01 | 1.02 | 1.03 | 1.00 | •95 | •93 | .87 | | | は記 |
| .0. | .69 | •76 | .82 | -85 | .86 | •94 | .90 | 1.00 | 1.01 | 1.02 | •99 | •95 | .92 | .86 | | - C | 취심 |
| .5. | -68 | •76 | .81 | •84 | .85 | .93 | •98 | 99 _ | 1,00 | _1.01_ | . 98 | - 94 | 92. | B5 | | | -2 |
| | .67 | .75 | .80 | .83 | +8+ | •92 | .97 | .98 | •99 | 1.00 | •97 | •93 | •91 | .84 | | | |
| 55.5 | | 77 | .83 | -86 | .87 | 95 | 1.00 | 1.01 | 1.02 | 1.03 | 1.00 | •96 | .93 | .87 | | | 무 |
| *
50.* | .73 | .81 | .86 | 90 | .90 | .99 | 1.05 | 1.06 | 1.06 | 1.08 | 1.04 | 1.00 | 98 | •91 | | | COEFFICIENT |
| 55 | •74 | .83 | .89 | •92 | •93 | 1.02 | 1.07 | 1.08 | 1.09 | 1.10 | 1.07 | 1.02 | 1.00 | •93 | | | E 17 |
| 70.0 | •80 | | 95 | | 1.00 | 1.09 | 1.15 | 1.16 | 1.17 | 1.19 | 1.15 | 1.10 | 1.08 | 1.00 | | | |
| | | | • • • | | | • | | • | | | | • | | | | | TABLES |
| | TABLE . | 55 | | | | | | | | | | | | | | | ř |
| | 5. | 10. | 15. | 20. | 25. | 30. | 35. | 40. | 45. | 50 | 55. | 60. | 65. | 70 | | | |
| • | | | | | -3.23 | | | | | -5.23 | -5.1 2 | -4.95 | -4.86 | -4.49 | | | Š |
| 5.0 | 0100 | 0.00 | ÷.83 | | -1.68 | | | | | | | | | | | | JUNE |
| 5.0 | 1 90 | | | -1.0-0 | -1.00 | -5.00 | -5114 | -3102 | -2450 | -2020 | -3.00 | | 5410 | | | | 7 |
| 10. | 1.25 | | | | | ···· | | | -35-34 | ***************************** | | | -2 24 | -7.06 | | | |
| 19.5 | 1.95 | .78 | 0.00 | ···•54 | | -1.42 | - • | | | -2.35 | | | | | | | 4 |
| 19.5 | 2.38 | .78
1•26 | .52 | 0.00 | 26 | 83 | -1.16 | -1.37 | -1.53 | ~1.70 | -1.70 | -1.67 | -1.65 | -1.51 | | | (MOD |
| 10.e
15.s
20.e | 1.95
2.38
2.59 | 1.26
1.50 | .52
.77 | | 26
0.00 | 83
54 | -1.16
85 | -1.37
-1.06 | -1.53 | -1.70
-1.39 | -1.70
-1.39 | -1.67
-1.38 | -1.65
-1.37 | -1.51 | | | (אוטטפר |
| 19.5 | 1.95
2.38
2.59 | .78
1•26 | .52 | 0.00 | 26 | 83 | -1.16 | -1.37
-1.06 | -1.53 | ~1.70 | -1.70 | -1.67 | -1.65
-1.37 | -1.51 | | | |
| 10.e
15.s
20.e | 2.38
2.59
2.59 | 1.26
1.50 | .52
.77 | •26 | 26
0.00 | 83
54 | -1.16
85 | -1.37
-1.06 | -1.53 | -1.70
-1.39 | -1.70
-1.39 | -1.67
-1.38 | -1.65
-1.37
84 | -1.51 | | | |
| 10.0 | 2.38
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2.59 | 1.26
1.50
1.93 | .52
.77 | 0.00
.26 | 0.00 | 83
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85 | -1.37
-1.06 | -1.53
-1.22
64 | -1.70
-1.39 | -1.70
-1.39
83 | -1.67
-1.38 | -1.65
-1.37
84 | -1.51
-1.25 | | | (Moder perived |
| 10.
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3.32 | 1.26
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2.15 | .52
.77
1.24 | 0.00
.26
.75 | 26
0.00
.49 | 83
54
h.00
.27 | -1.16
85
29 | -1.37
-1.06
49 | -1.53
-1.22
64 | -1.70
-1.39
80
51 | -1.70
-1.39
83
54 | -1.67
-1.38
83
56 | -1.65
-1.37
84
58 | -1.51
-1.25
76
51 | | | |
| 10.0
15.0
26.0
25.0
30.5 | 1.95
2.38
2.59
2.99
3.18
3.32 | 1.26
1.50
1.93
2.15 | .52
.77
1.24
1.47 | 0.00
.26
.75
.99 | 26
0-00
-49
-74 | 83
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.27 | -1.16
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29
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49
21 | -1.53
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15 | -1.70
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51 | -1.70
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54 | -1.67
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83
56
37 | -1.65
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84
58 | -1.51
-1.25
76
51 | | | |
| 10.0
15.8
26.0
25.0
30.5
35.0
40.0 | 1.95
2.38
2.59
2.99
3.18
3.32 | .78
1.26
1.50
1.93
2.15
2.21 | .52
.77
1.24
1.47
1.64 | 0.00
.26
.75
.99
1.16 | 26
0-00
-49
-74
-91 | 83
54
6.00
.27
.46 | -1.16
85
29
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.20 | -1.37
-1.06
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21
0.00 | -1.53
-1.22
64
35
15 | -1.70
-1.39
80
51
30 | -1.70
-1.39
83
54
34 | -1.67
-1.38
83
56
37 | -1.65
-1.37
84
58
39 | -1.51
-1.25
76
51
33 | | | |
| 10.0
15.8
26.0
25.0
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50.0 | 1.95
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3.32
3.42
3.53 | .78
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2.53 | .52
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1.47
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1.29 | 26
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.91
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-1.39
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34
19 | -1.67
-1.38
83
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23 | -1.65
-1.37
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-1.25
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33
21 | | | |

| June |
|-------|
| 1 |
| Mode1 |

Leave the second second

| | A TABLE
Ength≈ .: | 65 | | | | | | | | | | | | | |
|--|---|--|---|---|--|--|--|---|--|---|---|---|---|---|----------|
| | 5. | 10. | 15. | 20. | 25. | 30. | 35. | 40. | 45. | 50. | 55. | 60. | 65. | 70. | , |
| 5.5 | 1-00 | 1.10 | 1.19 | 1.23 | 1.26 | 1.38 | 1.46 | 1.48 | 1,50 | 1.53 | 2.49 | 1.44 | 1.42 | 1.33 | |
| 10. | •91 | 1.00 | 1.08 | 1.12 | 1.14 | 1.25 | 1.33 | 1.35 | 1.35 | 1.39 | 1.35 | 1.30 | 1.28 | 1.20 | |
| 15.0 | -84 | •92 | 1.00 | 1.03 | 1.05 | 1.16 | 1.23 | 1.24 | 1,26 | 1,28 | 1.25 | 1.21 | 1.19 | 1.11 | |
| 50. | | | .97 | 1.00 | 1.05 | 1.12 | 1.19 | 1.20 | 1.22 | 1.24 | 1.21 | 1.17 | 1.15 | 1.08 | |
| 25. | •80 | •88 | .95 | •98 | 1.00 | 1.10 | 1.16 | 1.18 | 1.17 | 1.22 | 1.18 | 1.14 | 1.13 | 1.06 | |
| 30.* | .72 | .80 | .86 | •89 | .91 | 1.00 | 1.06 | 1.07 | 1.03 | 1.11 | 1.08 | 1.04 | 1.02 | .96 | , |
| -35,* | 68 | - 75 | .81 | - 84 | .86 | . 95 | 1.00 | 1.01 | 1.02 | 1.05 | 1.02 | -98 | .97 | .91 | |
| 40. | •67 | -74 | .80 | .83 | .85 | •93 | 99 | 1.00 | 1.01 | 1.03 | 1.00 | •97 | • 95 | •90 | · |
| 45. | -67 | •73 | .80 | •82 | .84 | .92 | •98 | .99 | 1.0-) | 1.02 | •99 | •96 | .94 | .89 | l |
| 50. | -65 | .72 | .76 | •81 | .82 | .90 | •96 | .97 | ,90 | 1.00 | .97 | •94 | •93 | .87 | |
| 55. | 67 | •74 | .80 | •83 | .84 | .93 | .9a | 1.00 | 1.0 | 1.03 | 1.00 | •97 | •95 | -89 | |
| 60. | -70 | •77 | .83 | •86 | .87 | •96 | 1.02 | 1.03 | 1.04 | 1.06 | 1.03 | 1.00 | .98 | •92 | |
| 65. | .71 | 78 | .84 | .87 | .89 | .98 | 1.03 | 1.05 | 1.06 | 1.08 | 1.05 | 1.02 | 1.00 | .94 | |
| 70 | •75 | .83 | .90 | •93 | .95 | 1 • 0 4 | 1.10 | 1.12 | 1.13 | 1,15 | 1.12 | 1.08 | 1.07 | 1.00 | |
| RETA | TABLE | • | | | | | | | | | | | | | |
| | ENGTH= | 65
10. | 15. | 20. | 25. | 30. | 35. | 40• | 45. | 50. | 55. | 60. | 65. | 70. | |
| | | | | | | | | | | | | | | | |
| | | 0499900 | ***** | **** | *** | **** | ***** | **** | **** | 10 g##### | ***** | **** | **** | ***** | <u>'</u> |
| 5.* | 0.00 | 52 | 93 | | | | | | | -2.41 | ******* | *** | | | |
| 5.* | 0.00 | | | | -1.38 | -1.79 | -2.04 | -2.18 | -2.28 | **** | -2.37 | -2.31 | -2.29 | -2-14 | - |
| | 0.00 | 52 | 93 | -1.20 | -1.38 | -1.79 | -2.04
-1.35 | -2.18
-1.48 | -2.28 | -2.41 | -2.37
-1.66 | -2.31 | -2.29
-1.62 | -2.14
-1.51 | • |
| 15.0 | 0.00
.47
.78 | 52
0-00
-34 | 93
37 | -1.20 | -1.38
78 | -1.79
-1.14 | -2.04
-1.35 | -2.18
-1.48 | -2.28 | -2.41
-1.69 | -2.37
-1.66 | -2.31
-1.63 | -2.29
-1.62 | -2.14
-1.51 | |
| 15.a
20.a
20.a | 0.00
.47
.78
.98 | 52
0.00
.34
.56 | 93
37
0.00 | -1.20
62
24 | -1.38
78
39 | -1.79
-1.14
71 | -2.04
-1.35
90 | -2.18
-1.48
-1.02 | -2.28
-1.57
-1.11 | -2.41
-1.69
-1.21 | -2.37
-1.66
-1.20 | -2.31
-1.63
-1.19 | -2.29
-1.62
-1.18 | -2.14
-1.51
-1.10 | |
| 10.8 | 0.00
.47
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-14 | -1.38
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-1.14
71
44
27 | -2.04
-1.35
90
61 | -2.18
-1.48
-1.02
73 | -2.28
-1.57
-1.11
81 | -2.41
-1.69
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-1.66
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| 20.* | 0.00
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43 | -2.37 -1.66 -1.20917429 | -2.31
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74
45 | -2.29
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46 | -2.14
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-1.57
-1.11
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19 | -2.41 -1.69 -1.2191734328 | -2.37
-1.66
-1.20
91
74
44
29 | -2-31 -1-63 -1-1990744531 | -2.29 -1.62 -1.1891764632 | -2.14
-1.51
-1.10
84
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42
28 | |
| 15.a
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35.a
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50.a | 0.00
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.98
1.09
1.29
1.39
1.47
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1.57
1.59 | 52
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.56
.69
.91
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1.16
1.22 | 93
37
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.37
.61
.73
.82
.88 | -1.20
62
24
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.14
.39
.51 | -1.38
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.47 | -1.79 -1.14714427 0.00 .14 .24 .31 | -2.04
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15
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-1.48
-1.02
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26
11
0.00 | -2,28
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-81
-,64
-,34
-,19
-,08
0,00 | -2.41 -1.69 -1.219173432816 | -2.37
-1.56
-1.20
91
74
29
18 | -2-31 -1-63 -1-19907445312013 | -2.29 -1.62 -1.189176463221 | -2.14
-1.51
-1.10
84
42
28
19 | |
| 10.#
15.#
20.#
30.#
35.#
50.#
50.# | 0.00
.47
.78
.9B
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1.29
1.39
1.47
1.52
1.57
1.59 | 52
0.00
.34
.56
.69
.91
1.02
1.10
1.16
1.22
1.23
1.25 | 93
37
0.00
.23
.37
.61
.73
.82
.88
.95 | -1.206224 0.0014395150677475 | -1.38
78
39
15
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.25
.38
.47
.53
.60
.62
.64 | -1.79 -1.14714427 0.00 .14 .24 .31 .39 .41 .43 | -2.04
-1.35
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.17
.18
.26
.29 | -2.18 -1.48 -1.0273552611 0.00 .08 .16 .18 | -2.26 -1.57 -1.118164341908 0.00 .08 .11 | -2.41 -1.69 -1.21917343281608 | -2.37 -1.66 -1.209174291810 | -2-31 -1-63 -1-19907445312013 | -2.29 -1.62 -1.18917446322114 | -2.14
-1.51
-1.10
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19
12 | |
| 15. 20. 25. 35. 35. 35. 35. 35. 35. 35. 35. 35. 3 | 0.00
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.91
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1.16
1.22
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.73
.82
.88 | -1.20
62
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0.00
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.60
.67
.74 | -1.38
78
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.60 | -1.79 -1.14714427 0.00 .14 .24 .31 .39 | -2.04
-1.35
90
61
44
15
0.00
.17
.18
.26 | -2.18 -1.48 -1.0273552611 0.00 .08 .16 .18 | -2.26 -1.57 -1.138164341908 0.00 .08 | -2.41 -1.69 -1.21917343281608 | -2.37 -1.66 -1.2091744429181002 | -2.31 -1.63 -1.1990744531201305 | -2.29 -1.62 -1.1891764632211406 | -2.14
-1.51
-1.10
84
42
28
19
12
05 | |

| FER | TABLE | 5 | | | | | | 4.6 | 4.5 | #a | es | 40 | A.E. | 70. | |
|------------|--|--|--|---|--|---|----------------------------|---|---|---|-------------------------------------|-------------------------------------|---|---|--|
| | ១.
សេសសេសសេស | 10. | 15. | 20. | 25 · | 30 a | 350 e | 40*** | **** | ***** | **** | **** | *00000 | **** | |
| #
| 1.00 | 1.12 | 1.21 | 1.25 | 1.26 | 1.37 | 1+45 | 1.53 | 1.56 | 1.56 | 1.53 | 1.4B | 1.46 | 1.38 | |
| D | .89 | 1.00 | 1.09 | 1+11 | 1.13 | 1.23 | 1.30 | 1.37 | 1.39 | 1.40 | 1+37 | 1.32 | 1.31 | 1.23 | |
| <u>.</u> - | •B2 *** | :92- | 1.00 | 1.03 | 1.04 | 1.13 | 1.20 | 1.27 | 1.28 | 1.29 | 1.27 | 1.22 | 1.20 | 1-14 | |
| | .80 | •90 | .97 | 1.00 | 1.02_ | 1.10 | 1.17 | 1.23 | 1.25 | 1,26 | 1.23 | 1.18 | 1.17 | 1-11 | |
| | •79 | - 58 | .96 | •99 | 1.00 | 1 • 09 | 1.15 | 1.21 | 1.23 | 1.24 | 1.21 | 1.17 | 1.16 | 1.09 | |
| | 73 | B1 | .88 | •91 | .92 | 1.00 | 1.06 | 1.12 | 1.13 | 1.14 | 1.12 | 1.08 | 1.06 | 1.00 | |
| 6
6 | -69 | •77 | .83 | -86 | .87 | .94 | 1.00 | 1.06 | 1.07 | 1.08 | 1.06 | 1.02 | 1.01 | .95 | |
| 9 | .65 | •73 | .79 | •81 | •82 | .89 | •95 | 1.00 | 1.01 | 1.02 | 1.00 | •96 | •95 | •90 | |
| . B | | 72 | .78 | -80 | .81 | 88 | .93 | .99 | T.00 | 1.01 | •99 | •95 | •94 | .89 | |
| | -64 | •71 | .77 | +80 | .81 | .88 | •93 | .98 | .99 | 1.00 | •98 | •94 | .93 | .88 | |
| | •65 | .73 | .79 | .61 | .82 | .89 | •95 | 1.00 | 1.01 | 1.02 | 1.00 | •96 | •95 | . 90 | |
| | .68 | .76 | .82 | -84 | .86 | 93 | •98 | 1.04 | 1.05 | 1.06 | 1.04 | 1.00 | • 59 | .93 | |
| | 68 | <u>•77</u> _ | .83 | -85 | .87 | •94 | 1.00 | 1.05 | 1.06 | 1.07 | 1.05 | 1.01 | 1 00 | .94 | |
| | .73 | .81 | .88 | • 90 | .92 | 1.00 | 1.05 | 1-11 | 1.13 | 1.14 | 1.11 | 1.07 | 1.06 | 1.00 | |
| | | | | | | | | | | | | | | | |
| τ | TARI F | | | | | | | | | | | | | | |
| | TABLE
NGTH= . | | | 20. | 25. | 70. | 75. | 40• | 45. | 50. | 55. | 60. | 65• | 70. | |
| ELEI | NGTH=
5. | 10. | | 20. | 25.
••••• | 30. | 35. | | 45, | 50. | 55.
64000es | | 65. | | |
| ELEI | NGTH= . | 10. | **** | | | | ****** | 40.
8000000 | 0000000 | 6690400 | | ****** | 800000 | | |
| ELEI | NGTH= . | 10. | **** | 00#400# | ******* | **** | ****** | -1.10 | 0000000 | 6690400 | ***** | ****** | 800000 | -1.08 | |
| ELE! | 5.
5.
6.00 | 10. | -,44 | **57 | 65 | **** | + • 97 | -1.10 | -1.16 | -1.20 | -1.19 | -1-16 | -1.15 | -1.08 | |
| ELEI | 0.00
+22 | 10.
25
c-00 | 44
17 | ++57
-+29 | 65
37 | 84
54 | 65 | -1.10
77 | -1.16
82 | -1.20
86 | -1.19
86 | -1.16
63 | -1.15
83 | -1.08
78 | |
| E_E | 0.00
-22 | 10.
25
c-00 | 44
17
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| 5. | | 1-11 | 1.21 | 1.24 | 1.26 | 1.36 | 1.44 | 2.19 | 1.50 | 1.56 | 1.54 | 1.48 | 1.47 | 1.39 | |
| 10. | | 1.00 | 1.08 | 1.11 | 1.12 | | | 1.97 | 1.4[| 1.40 | 1.38 | 1.33 | 1.32 | 1.25 | |
| 15.0 | .83 | -92 | 1.00 | | 1.04 | | 1.19 | | | 1.30 | 1.27 | 1.22 | 1.21 | 1.15 | |
| 20. | .81 | .90 | .98 | 1.00 | 1.01 | _ 3555 _
1+10 | 1.16 | 1.77 | 1,26 | 1.26 | 1.24 | 1.19 | 1.18 | 1.12 | |
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| 30. | .73 | | .69 | | | | | | | | | | | | |
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| - 40.6 | •69 | .77 | .64 | •86
 | .87 | •95
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| 45.0 | | | .55 | -56 | .57 | .62 | _ | | ,71 | | •70
• 00 | +67 | •67 | •63 | |
| 50.0 | .64 | •72 | .78
.77 | •80
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| _ 55.a | | | | | | | •92 | | | 1.00 | | | | | |
| • | -65 | •72 | .78 | •80 | .82 | .88 | •94 | | 1.01 | 1.02 | 1.00 | •96 | .95 | .90 | |
| 60. | .68 | • 75 | -85 | •84 | .85 | .92 | •98 | | <u>1</u> .05_ | 1.06 | 1.04 | 1.00_ | 99 | . 94 | |
| 65.0 | •6B | •76 | .82 | •85 | .86 | •93 | •9R | 1.50 | 1.06 | 1.07 | 1.05 | 1.01 | 1.00 | •95
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| 70.4 | .72 | -80 | .B7 | •89 | .90 | -98 | 1.04 | 1.58 | 1.12 | 1.13 | 1+11 | 1.06 | 1.06 | 1.00 | |
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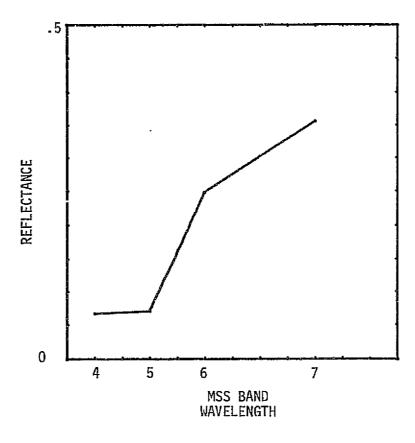
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 $(1, \dots, 1) \in \mathbb{R}^{2n} \times \mathbb{R}$

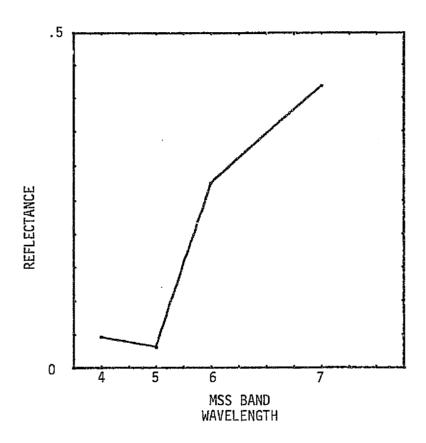
A CONTRACTOR OF THE STATE OF TH

APPENDIX B: VARIATION OF WHEAF CANOPY REFLECTANCE WITH SUN ANGLE (EMPIRICAL DATA)

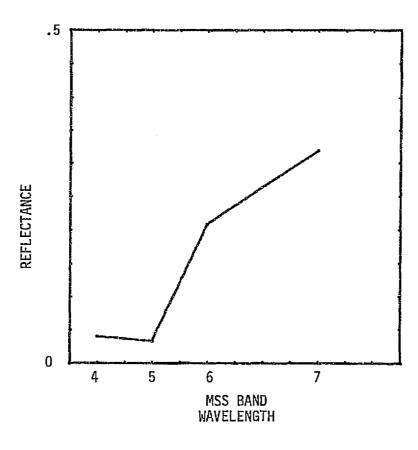
| | | Page |
|-----|--|------|
| 1.0 | Average Spectral Signatures
March, April, May, June | B.1 |
| 2.0 | March 20, 1975
MSS Bands 4, 5, 6, 7 | B.5 |
| 3.0 | April 23, 1975
MSS Bands 4, 5, 6, 7 | B.9 |
| 4.0 | May 20, 1975
MSS Bands 4, 5, 6, 7 | B.13 |
| 5.0 | June 26, 1975
MSS Bands 4, 5, 6 | B.17 |



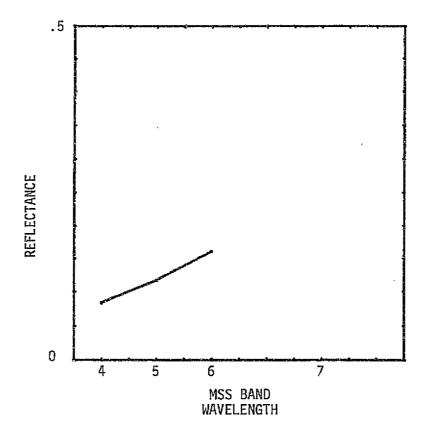
Wheat Canopy Reflectance for March 20 Averaged Over All Sun Angles and LAI (Empirical Data)



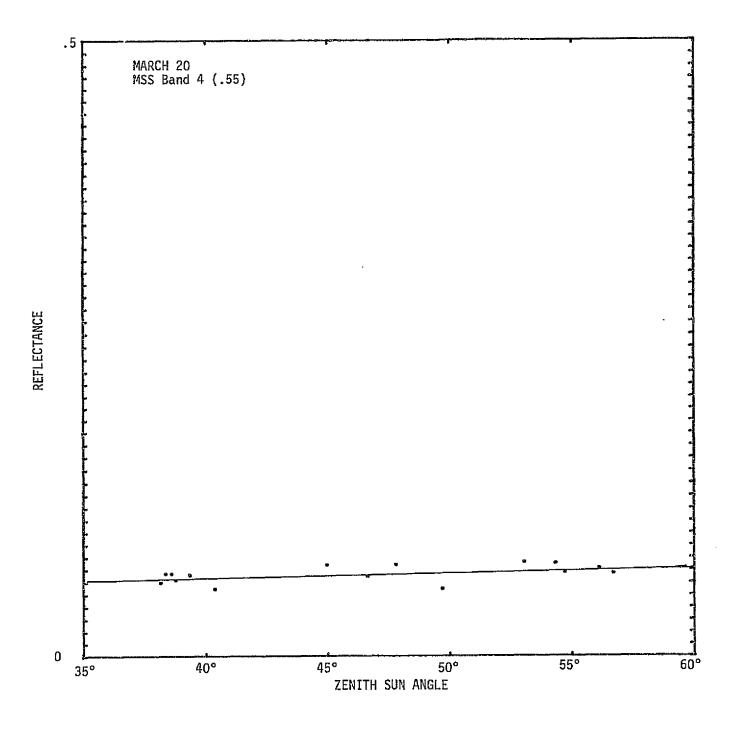
Wheat Canopy Reflecatnce for April 23 Averaged Over All Sun Angles and LAI (Empirical Data)

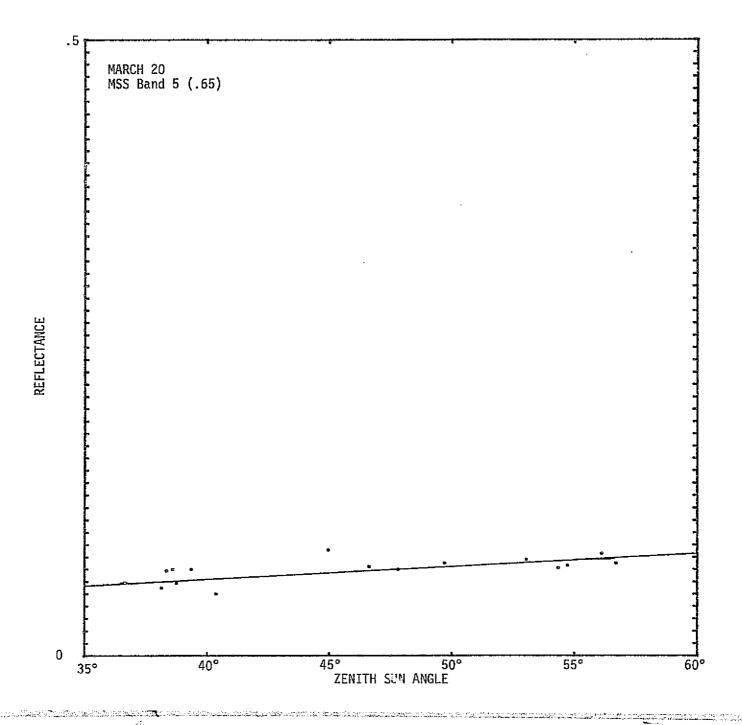


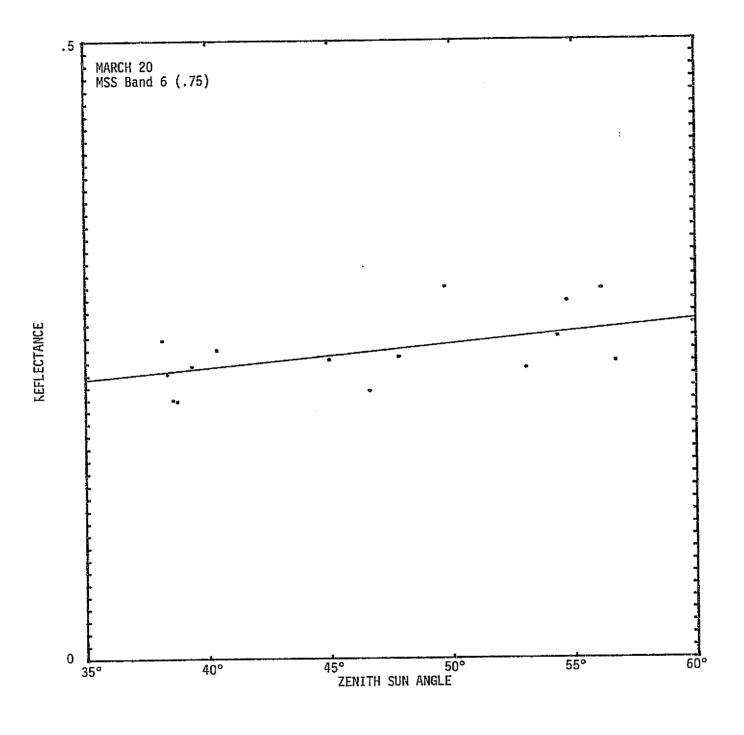
Wheat Canopy Reflectance for May 20 Averaged Over All Sun Angles and LAI (Empirical Data)

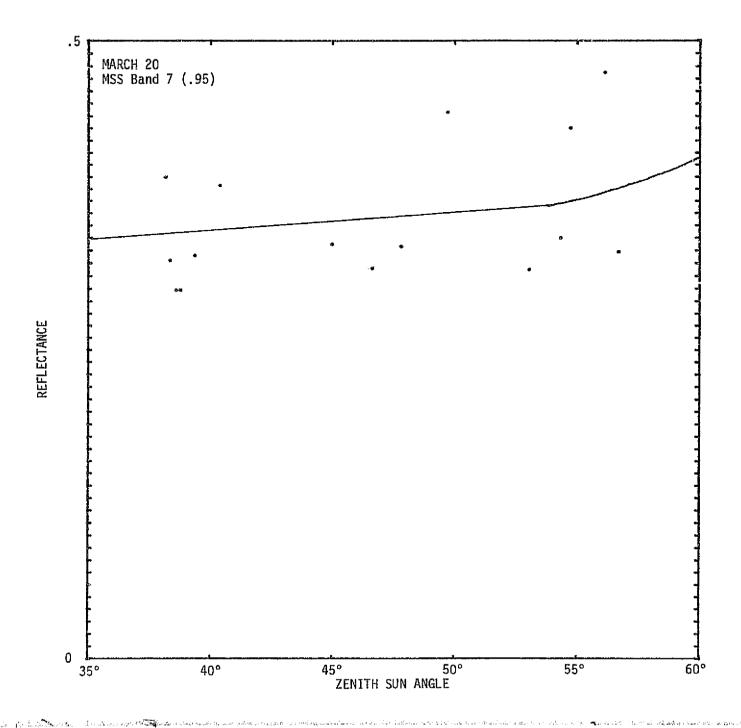


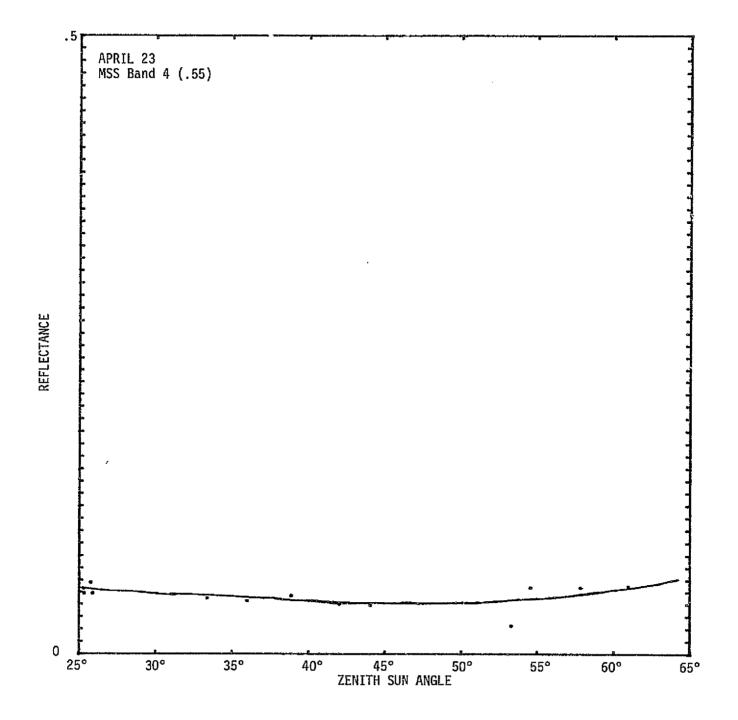
Wheat Canopy Reflectance for June 26 Averaged Over All Sun Angles and LAI (Empirical Data)

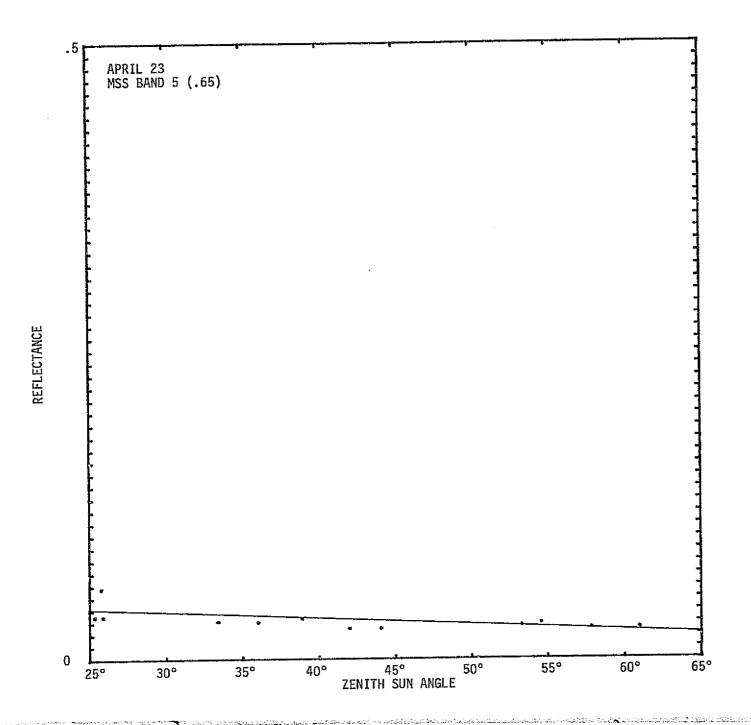


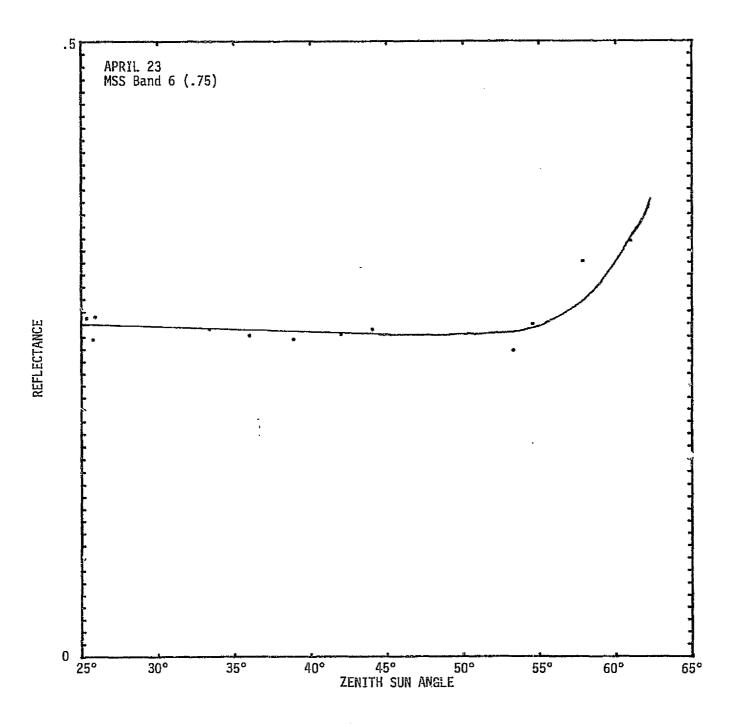


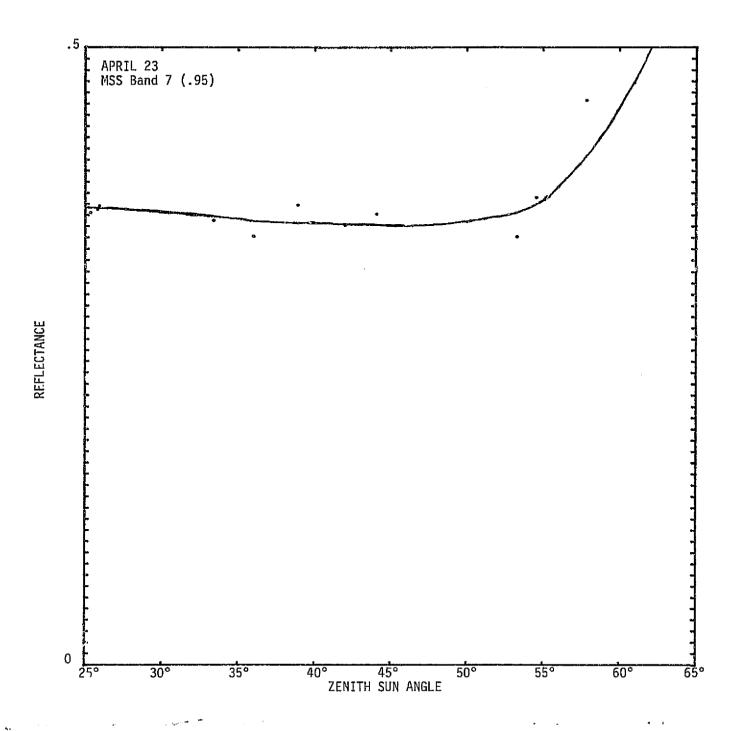




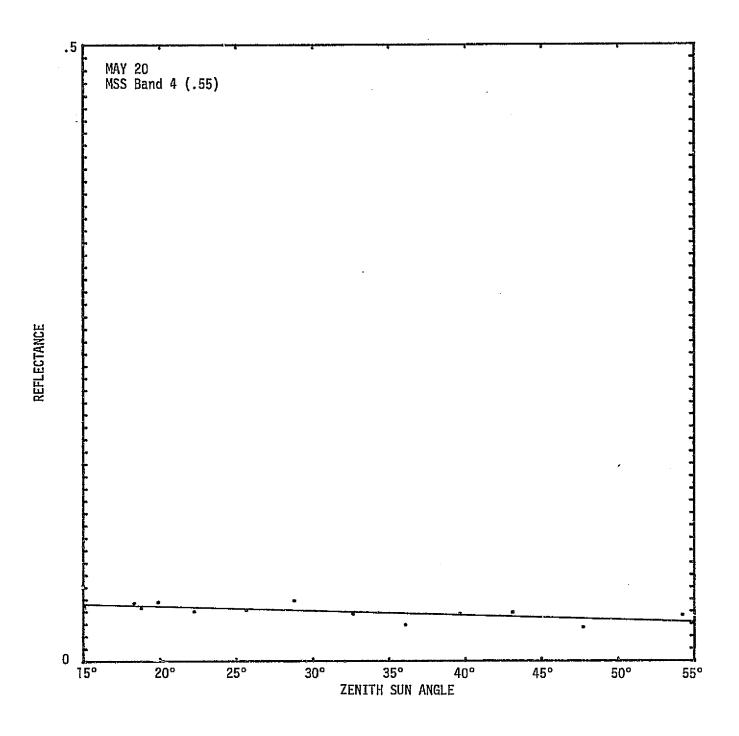




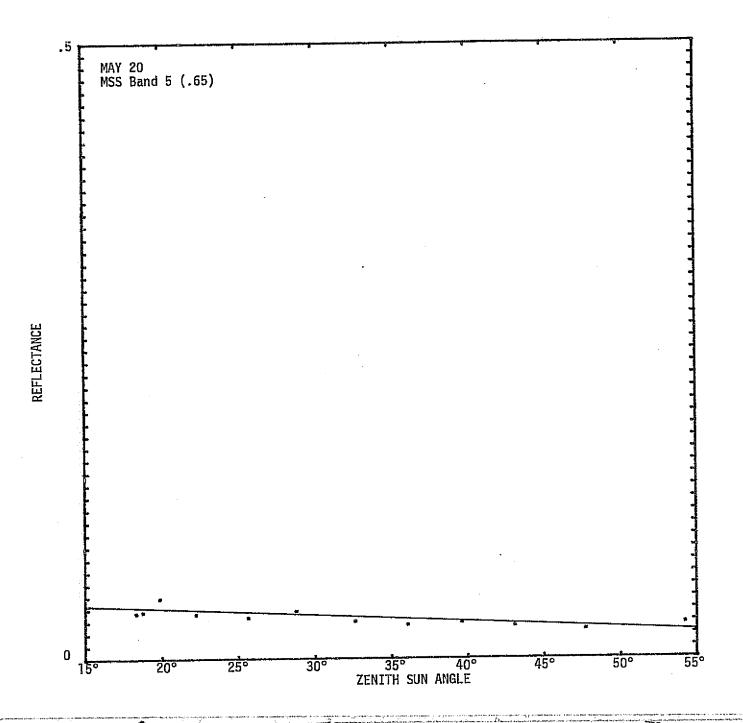


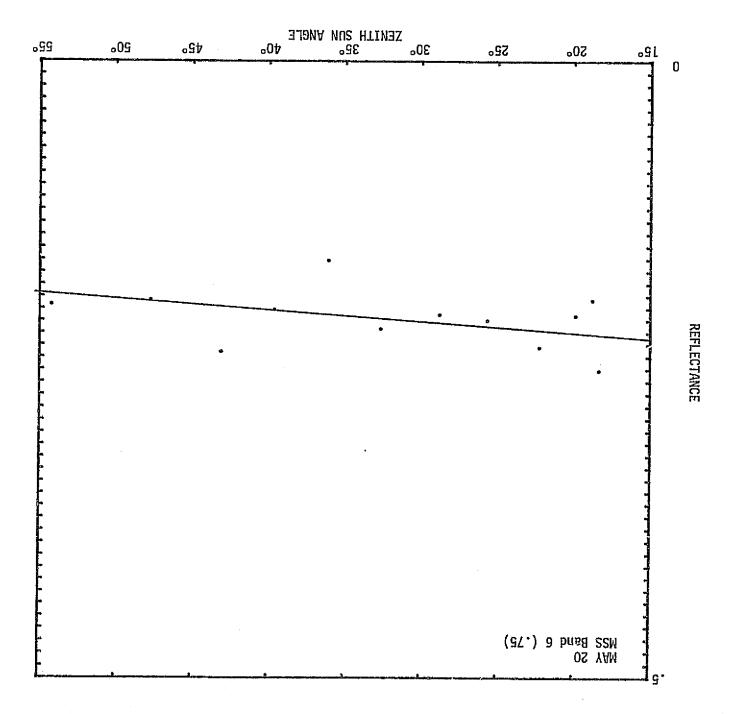


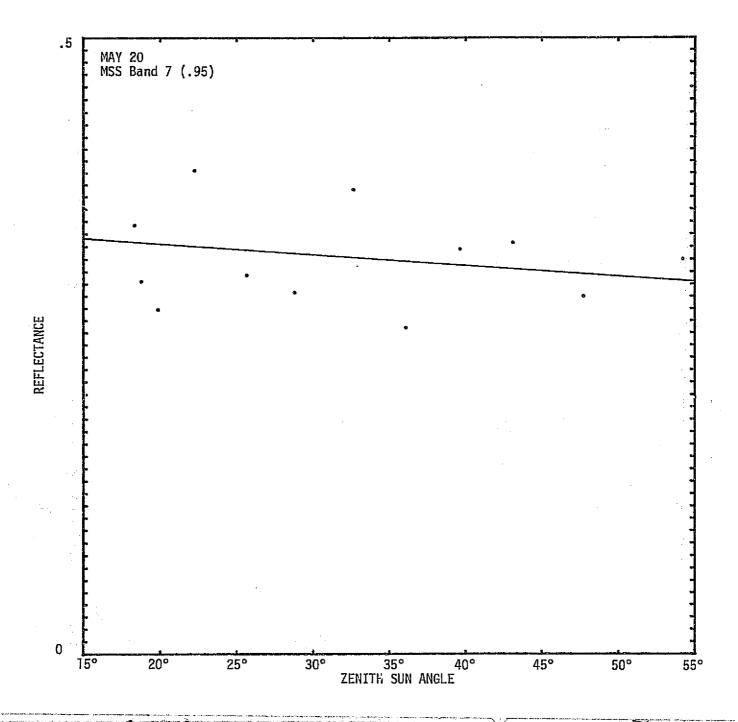


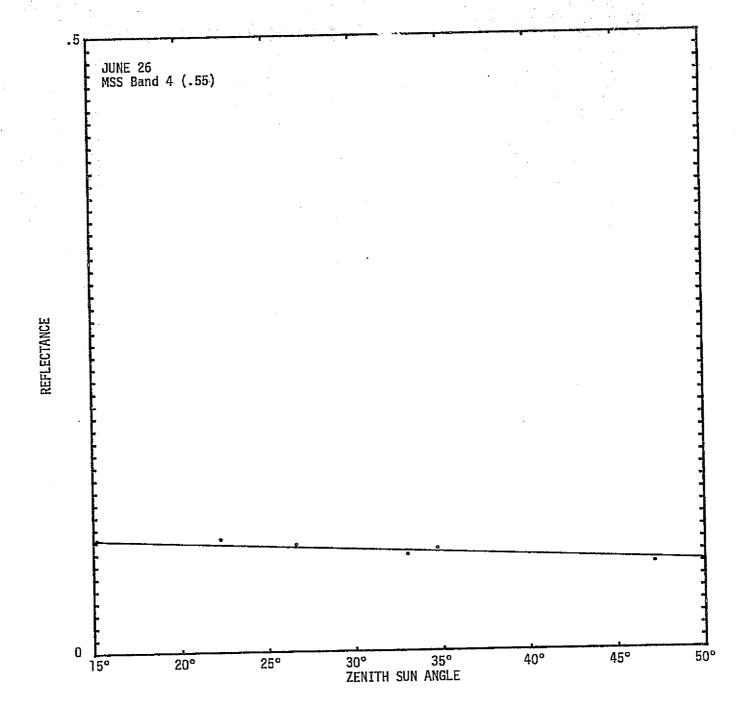


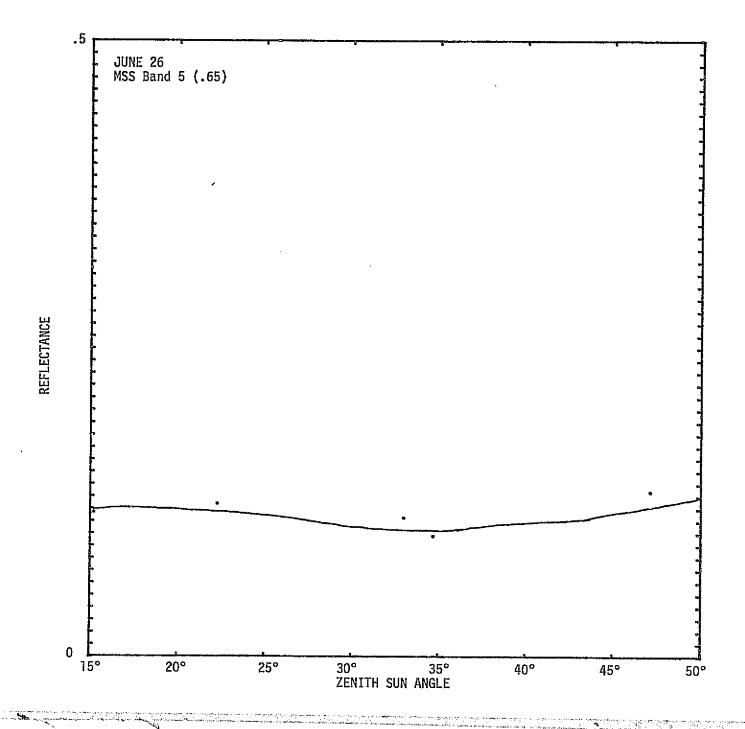
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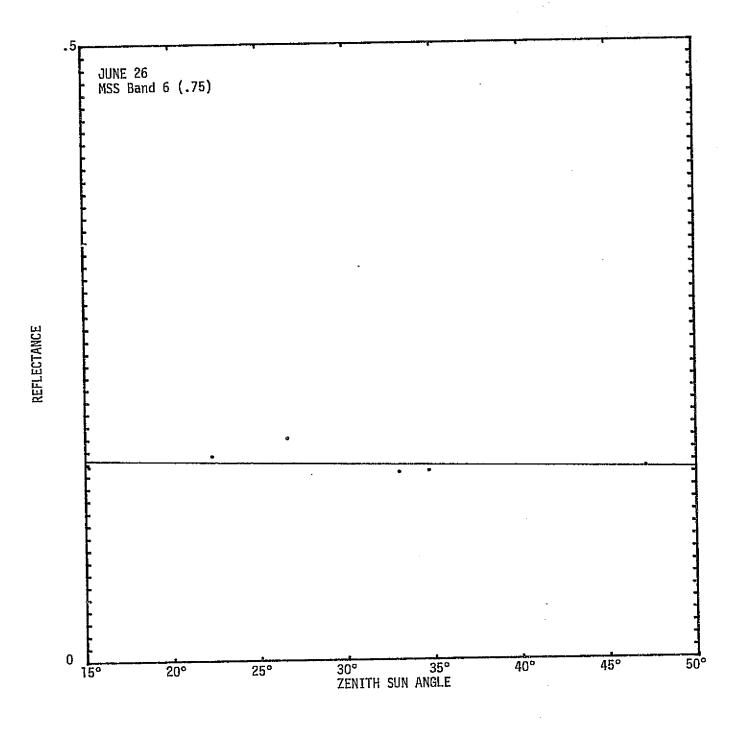












APPENDIX C

SUMMARY TABLES FOR SUN ANGLE RELATIONSHIPS

TABLE C.1

EMPIRICAL SUN ANGLE
EFFECTS ON SCENE REFLECTANCE
(For an Average LAI)

| SUN
ANGLE | MSS4 | MSS5 | MSS6 | MSS7 | SUN
ANGLE | MSS4 | MSS5 | MSS6 | MSS7 |
|---------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|---------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
| March
38°Z
39
47
53
57 | .062
.067
.065
.076
.067 | .059
.070
.072
.078
.075 | .209
.210
.217
.235
.240 | .299
.299
.316
.315
.329 | April
25°Z
36
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58 | .049
.043
.039
.054 | .035
.030
.025
.025 | .275
.261
.266
.321 | .402
.381
.401
.503 |
| May
19°Z
26
36
48 | .043
.041
.029
.027 | .038
033
.027
.023 | .193
.210
.161
.193 | .302
.307
.264
.290 | June
15°Z
22
27
35 | .092
.092
.087
.083 | .117
.124
.116
.098 | .158
.166
.180
.153 |

 |

TABLE C.2

| | | MARCH | | | | | APRIL | | |
|---|---|--|---|---|---|--|--|---|--|
| SUN 4. 5°Z 10 15 20 25 30 35 40 45 50 65 70 | 4
.028
.029
.030
.033
.036
.039
.041
.044
.047
.049
.053
.065 | 5
.022
.022
.025
.027
.029
.031
.033
.035
.035
.038
.047
.052 | 6
.136
.142
.148
.165
.182
.196
.210
.225
.239
.257
.279
.343
.393
.452 | 7
.189
.198
.206
.229
.251
.269
.287
.307
.327
.352
.383
.467
.534 | SUN x . 5° Z 10 15 20 25 30 35 40 45 50 65 70 | 4
.031
.033
.035
.038
.041
.042
.043
.053
.054
.059
.065 | 5.021
.023
.024
.026
.028
.029
.030
.034
.037
.038
.041
.045 | 6.164
.177
.189
.204
.218
.226
.233
.258
.283
.292
.318
.349
.402
.467 | 7
.230
.246
.262
.282
.302
.314
.325
.359
.392
.405
.440
.483 |
| | | MAY | | | | | JUNE | | |
| 5°Z
10
15
20
25
30
35
40
45
50
55
60
65
70 | .023
.024
.025
.028
.030
.033
.037
.039
.041
.046
.050
.056 | .016
.017
.018
.020
.021
.024
.026
.028
.029
.033
.036
.040
.046 | .125
.133
.141
.152
.163
.183
.202
.215
.227
.252
.273
.305
.348
.409 | .177
.188
.198
.214
.229
.256
.282
.299
.316
.349
.377
.420
.477 | 5°Z
10
15
20
25
30
35
40
45
50
55
60
65
70 | .048
.054
.059
.063
.066
.076
.085
.092
.101
.113
.124
.138
.162 | .052
.058
.064
.068
.072
.083
.093
.101
.111
.125
.137
.153
.180 | .100
.113
.125
.132
.139
.158
.177
.200
.220
.244
.269
.298
.351 | .118
.133
.147
.155
.163
.185
.207
.336
.259
.287
.317
.350
.412 |

TABLE C.3

MODEL GENERATED SUN ANGLE EFFECTS ON SATELLITE SENSED TOTAL RADIANCE (Milliwatts/Square Centimeter/Steradian/Micrometer)

| | | 100 | | | | | | | |
|--|--|---|--|--|---|--|--|---|---|
| SUN
Angle | MSS4 | MSS5 | MSS6 | MSS7 | SUN
ANGLE | MSS4 | MSS5 | MSS6 | MSS7 |
| MARCH 5° Z 10 15 20 25 30 35 40 45 50 65 70 | 5.901
5.053
4.456
4.123
3.950
3.699
3.517
3.324
3.129
2.907
2.754
2.724
2.588
2.721 | 3.032
2.715
2.512
2.372
2.290
2.164
2.053
1.949
1.658
1.616
1.628
1.548
1.659 | 6.029
6.055
6.028
6.323
6.569
6.619
6.614
6.915
6.372
6.166
5.946
6.320
6.129
7.154 | 5.166
5.271
5.314
5.656
5.907
5.987
5.995
5.953
5.819
5.662
5.473
5.834
6.649 | APRIL
5° Z
10
15
20
25
30
35
40
45
50
55
60
65
70 | 5.991
5.230
4.716
4.375
4.153
3.815
3.590
3.460
3.315
3.048
2.903
2.724
2.606
2.454 | 2.991
2.756
2.552
2.411
2.328
2.164
2.019
1.981
1.973
1.685
1.588
1.548 | 7.014
7.273
7.462
7.619
7.691
7.507
7.280
7.445
6.936
6.712
6.408
6.292
5.993 | 6.145
6.481
6.739
6.927
7.045
6.924
6.741
6.895
6.915
6.006
5.892
5.631 |
| MAY
5°Z
10
15
20
25
30
35
40
45
50
55
60
65
70 | 5,589
4.744
4.197
3.870
3.667
3.429
3.335
3.121
2.942
2.823
2.679
2.532
2.428
2.286 | 2.743
2.470
2.272
2.139
2.028
1.949
1.884
1.792
1.684
1.569
1.487
1.430
1.364 | 5.397
5.500
5.586
5.726
5.833
6.325
6.239
6.048
6.052
5.825
5.654
5.451
5.197 | 4.653
4.836
4.959
5.171
5.306
5.625
5.834
5.764
5.610
5.615
5.388
5.245
5.063
4.844 | JUNE
5°Z
10
15
20
25
30
35
40
45
50
65
70 | 6.708
6.072
5.672
5.347
5.129
5.095
5.090
4.926
4.756
4.660
4.505
4.386
4.221
4.000 | 4.233
4.148
4.148
4.011
3.945
4.067
4.155
4.610
4.013
3.988
3.910
3.879
3.754
3.610 | 4.521
4.807
4.807
5.064
5.068
5.367
5.603
5.700
5.714
5.689
5.554
5.375 | 3.215
3.510
3.510
3.813
3.841
4.117
4.327
4.449
4.466
4.481
4.532
4.532
4.533
4.434
4.302 |

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

APPENDIX D

SUMMARY TABLES FOR LEAF-AREA-INDEX RELATIONSHIPS

TABLE D.1

EMPIRICAL LAI EFFECTS REFLECTANCE DATA AT SURFACE (Standard Deviations Shown in Parentheses)

| <u>DATE</u> | LAI | MSS4 | MSS5 | MSS6 | MSS7 |
|-------------|------|----------------------------|------------------|---------------------------|------------------|
| MARCH | 1.31 | .07100
(<u>+</u> .002) | .07675
(.005) | .29775
.021) | .47500
(.029) |
| | 2.07 | .07625
(.002) | .07800
(.002) | .23475
(.016) | .31975
(.019) |
| | 4.06 | .07975
(.002) | .07125
(.006) | .26000
(.012) | .34000
(.023) |
| APRIL | | | | | |
| W WT | 5.13 | .04100
(.006) | .0265
(.007) | .26 2 25
(.015) | .38050
(.023) |
| | 5.36 | .03925
(.001) | .02475
(.001) | .26600
(.021) | .40125
(.048) |
| | 6.15 | .03975
(.007) | .02475
(.005) | .26150
(.044) | .39125
(.054) |

TABLE D.2

MODEL LAI EFFECTS REFLECTANCE DATA AT SURFACE (UNSMOOTHED)

| DATE | LAI | MSS4 | MSS5 | MSS6 | MSS7 | mss75 |
|-------|-----|--------|-------|-------|--------|--------|
| MARCH | 0.5 | .0432 | .0450 | .1490 | .2002 | 4.449 |
| | 1.0 | .0524 | .0450 | .2386 | .3257 | 7.238 |
| | 1.5 | .0470 | .0369 | .2334 | .3198 | 8.667 |
| | 2.0 | .0535 | .0418 | .2642 | .3607 | 8.629 |
| | 2.5 | .0487 | .0352 | .2574 | .3528 | 10.023 |
| | 3.0 | .0532 | .0381 | .2788 | .3801 | 9.976 |
| | 3.5 | .0537 | .0385 | .2820 | .3845 | 9.987 |
| | 4.0 | .0538 | .0378 | .2853 | .3889 | 10.288 |
| | 4.5 | .0562 | .0395 | .2972 | .4045 | 10.241 |
| | 5.0 | .0562 | .0395 | .2974 | .4051 | 10.256 |
| | | | | | | |
| APRIL | 3.5 | . 0504 | .0351 | 2604 | 2720 | 10 691 |
| | | | | .2694 | .3728 | 10.621 |
| | 4.0 | .0508 | .0354 | .2721 | .3781 | 10.681 |
| | 4.5 | .0519 | .0362 | .2773 | .3845 | 10.622 |
| | 5.0 | .0496 | .0345 | .2663 | .3711 | 10.757 |
| | 5.5 | .0511 | .0356 | .2734 | .3786 | 10.635 |
| | 6.0 | .0506 | .0352 | .2708 | .3750 | 10.653 |
| | 6.5 | .0503 | .0350 | .2691 | .3726 | 10.646 |
| | 7.0 | .0494 | .0344 | .2638 | .3647 | 10.602 |
| | 7.5 | .0494 | .0343 | .2636 | . 3645 | 10.627 |
| | 8.0 | .0494 | .0343 | .2636 | .3645 | 10.627 |

TABLE D.3

MODEL LAI EFFECTS RADIANCE
DATA AT SATELLITE (SMOOTHED)

(Milliwatts/Square Centimeter/Steradian/Micrometer)

| DATE | LAI | MSS4 | MSS5 | MSS6 | MSS7 | mss75 |
|-------|-----|-------|-------|-------|-------|-------|
| MARCH | 0.5 | 2.699 | 1.922 | 3.659 | 3.208 | 1.670 |
| | 1.0 | 2.951 | 1.922 | 5.630 | 5.137 | 2.672 |
| 4 | 1.5 | 2.803 | 1.714 | 5.515 | 5.046 | 2.944 |
| (| 2.0 | 2.982 | 1.840 | 6.196 | 5.678 | 3.086 |
| | 2.5 | 2.850 | 1.670 | 6.046 | 5.556 | 3.327 |
| | 3.0 | 2.973 | 1.745 | 6.519 | 5.978 | 3.426 |
| | 3.5 | 2.987 | 1.755 | 6.590 | 6.046 | 3.445 |
| | 4.0 | 2.990 | 1.768 | 6.664 | 6.114 | 3.862 |
| | 4.5 | 3.056 | 1.781 | 6.928 | 6.355 | 3.568 |
| | 5.0 | 3.056 | 1.781 | 6.932 | 6.365 | 3.574 |
| | | | | | | |
| APRIL | 3.5 | 3.455 | 1.986 | 7.595 | 7.049 | 3.549 |
| | 4.0 | 3.469 | 1.995 | 7.668 | 7.147 | 3.582 |
| | 4.5 | 3.505 | 2.020 | 7.807 | 7.266 | 3.597 |
| | 5.0 | 3.429 | 1.967 | 7.513 | 7.017 | 3.567 |
| | 5.5 | 3.479 | 2.001 | 7.702 | 7.157 | 3.577 |
| | 6.0 | 3.462 | 1.989 | 7.633 | 7.090 | 3.565 |
| | 6.5 | 3.452 | 1.983 | 7.587 | 7.045 | 3.553 |
| | 7.0 | 3,422 | 1.964 | 7.446 | 6.898 | 3.512 |
| | 7.5 | 3.422 | 1.961 | 7.441 | 6.894 | 3.516 |
| | 8.0 | 3.422 | 1.961 | 7.441 | 6.894 | 3.516 |